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CONTENTS AND INDEX.

NEW SERIES. VOL. LVIII.—JULY TO DECEMBER, 1923

THE NAMES OF CONTRIBUTORS ARE PRINTED IN SMALL CAPITALS

Acidity, Subsoil, A. P. KELLEY, 36
ADAIR, G. S., Donnan Equilibrium and Equation of Gibbs, 13
Agassiz and School at Penikese, E. S. MORSE, 273
AHRENS, T. G., Preservation of Wisent, 107
Airships, Ancient Reference to, A. A. EHRENFELD, 179
AITKEN, R. G., Our Knowledge of the Universe, 381
Aldred Lectures of Massachusetts Institute, 344
Aldrich Collection of Diptera, 301
ALEXANDER, J., and J. M. CONNOLLY, Casts, *vs.* Cylindroids, 68
ALLEE, W. C., American Society of Zoologists, 368
ALLEN, E. W., Administration of Agricultural Research, 499
ALLEN, W. E., Thresher Shark, 32
ALLEN, W. F., Warning to Microscope Users, 445
American Association for the Advancement of Science, Los Angeles Meeting of, W. W. SARGEANT, 23, 117, 138, 333; Philological Sciences, B. E. LIVINGSTON, 42; Cincinnati Meeting of, B. E. LIVINGSTON, 61, 327, 485; Section K at Cincinnati, F. L. HOFFMAN, 260; Section G at Cincinnati, R. B. WYLIE, 345; Pennsylvania State College Branch, 391; Meeting of Executive Committee, B. E. LIVINGSTON, 402; Membership in, B. E. LIVINGSTON, 404; Prize of, 438; History of Science Section at Cincinnati, F. E. BRASCH, 512; Medical Sciences at Cincinnati, A. J. GOLDFARB, 514; Address of the President, J. P. MCMURRICH, 521
Americanists, Congress of, 367
Amphioxus Fisheries in China, S. F. LIGHT, 57
Andes in Northern Peru, C. H. EIGENMANN, 532
ANDRUS, E. C., and E. P. CARTER, Normal and Abnormal Cardiac Rhythm, 376
ANTEVS, E., Climatic Changes, 420
Anthoceros, Sporophyte in, D. H. CAMPBELL, 307
Apothecia, Sclerotinia, Hydrogen Ion Concentration and Development of, W. N. EZEKIEL, 166
Apples, Worms, Philosophers and Goats, F. H. PIKE, 349
ASHWORTH, J. H., Modern Zoology, 231
Astronomical, Society, American, J. STEBBINS, 334; Observatory of University of Michigan, Publications of, R. H. BAKER, 467
Astronomy and Civilization, E. P. LEWIS, 405
Atmometry, Blackened Spheres for, B. E. LIVINGSTON, 182
AUER, J., Brown-Séquard's Epilepsy in Guinea Pigs, 109; Referred Sensations in Guinea Pigs, 183
Automobile Headlights, Adjustment of, 326

Bacon, Walter Rathbone, Scholarship, W. DE C. RAVENEL, 44
Bacteria, Iron-depositing, O. L. INMAN, 13
Bailey, Dr. E. H. S., Celebration in honor of, 301
Baird, Spencer Fullerton, M. BENJAMIN, 111
BAKER, F. C., University Natural History Museum, 55
BAKER, R. H., Publications of the Astronomical Observatory of University of Michigan, 467
BARBOUR, T., Friends of Medical Progress, 507
Batrachians, Voice as Factor in Mating of, G. K. NOBLE, 270
BAUER, L. A., Atmospheric Potential Gradient, 67; Earth's Magnetic Field, 113
BEACH, J. R., "Vitamin A," 542
BENEDICT, R. C., Conservation of Wild Plants, 39
BENJAMIN, M., Spencer Fullerton Baird, 111
BENTLEY, M., Applied Science and Science Applied, 69
Bergen Museum, Norway, Marine Biological Station of, A. BRINKMANN, 24
BEVAN, A., Peculiar Hail, 443
BIGELOW, L. A., and K. R. BOYES, Organic Chemical Transformations, 446
Biggs, Hermann M., 279, 413
BINGHAM, E. C., Subjects for Research, 100
Biological, Laboratory at Cold Spring Harbor, 137; Abstracts, 236; Societies, American, Union of, I. F. LEWIS, 257
Biology, British Journal of Experimental, 102
Birds, World Protection of, 198
Birkhoff, G. D., Relativity and Modern Physics, L. P. EISENHART, 539
BLEILE, A. M., and R. J. SEYMOUR, Formaldehyde and Vitamin Content of Milk, 518
Blood Sugar, W. THALHIMER and M. C. PERRY, 120
Bohr, Dr. Niels, 533
BORING, A. M., Chromosomes of Domestic Chicken, 73
BORING, E. G., Filing Reprints, 329
Boron Nitride, Vibrational Isotope Effect in Band Spectrum of, R. S. MULLIKEN, 164
Bouvier, E. L., Psychic Life of Insects, V. KELLOGG, 423
BRASCH, F. E., History of Science Section, 512
Bread, 117
BRINKMANN, A., Bergen Marine Biological Research Station, 24
British Association for the Advancement of Science, Liverpool Meeting of, 9, 176, 280, 325; B. E. LIVINGSTON, 27
BROOKS, C. F., Free-Air Pressure Maps, C. L. MEISINGER, 122
Buffalo Herd of Canada, 281
BURD, J. S., and J. C. MARTIN, Phosphate Behavior in Soils, 227
BURK, D. T., Water Glass as Mounting Medium, 13
BURKE, H. E., Pacific Coast Entomological Society, 354

CAIRNS, W. D., Mathematical Association of America, 392
CALKINS, F. C., American Educator and Scientist, 107
CALVERT, P. P., History of National Culture of Costa Rica, L. F. Gonzalez, 71
CAMPBELL, D. H., Sporophyte in Anthoceros, 307
CAMPBELL, E. G., What is a Weed? 49
CAMPBELL, W. W., Membership of National Academy of Sciences, 324; Fire at University of California, 348
Canada, Buffalo Herd of, 281; Pulpwood Resources of, 156
Cancer, Mortality from, 510
CANNON, W. A., Root Growth and Oxygen, 331
Carbon Disulphide and Aldehydes, E. WERTHEIM, 494
CARTER, E. P., and E. C. ANDRUS, Normal and Abnormal Cardiac Rhythm, 376
CASE, E. C., Fortschritte der Geologie und Paleontologie, F. B. Nopsca, 517
Castor Bean, Poisonous Action of, W. J. ROBBINS, 305
Casts, Examination of, J. ALEXANDER and J. M. CONNOLLY, 68
Cerebellum, Function of, K. MIURA, 361

Chemical, Bibliography, C. J. West, 44; Industries, Annual Exposition of, 109; Laboratories, Medicine and Related Arts in, W. C. Woodward, 204; Research, Industry and, 306; Society, American, C. L. Parsons, 271; G. Edgar, 309; M. Walker, 404; E. H. Volwiler, 427; L. C. Newell, 428; R. R. Renshaw, 469; Organic Transformations, L. A. Bigelow and K. R. Boyes, 446
Chemistry, International Union of Pure and Applied, J. E. Zanetti, 239; Prizes in, 243; and Modern Life, J. W. McBain, 429
Chemists in High Places, 228; Contemporary, Seminar on, 367
Chen, C. C., New Vacuum Pump, 17
Chidester, F. E., Sex Determination in Pigeons, 422
Chromosomes of Domestic Chicken, A. M. Boring, 73
Clark, G. L., and W. Duane, X-Ray Reflections, 400
Clayton, H. H., World Weather, R. deC. Ward, 267
Climatic Changes, E. Antevs, 420
Coal, Mining Problems, Fellowships in, 224; Coking, Structure and Origin of, E. C. Jeffrey, 285
Coleman, L. V., New Era for American Museums, 172
Color Hearing, M. D. H. Prang, 421
Conditioned Reflexes, I. P. Pawlow, 359
Conn, H. J., Certified Methylen Blue, 41
Cooley, Mortimer E., Retirement of, as President of American Engineering Council, 327, 534
Copepod, in Finger Lakes, N. Y., C. Juday, 205
Cowdry, E. V., Internal Reticular Apparatus of Golgi in Cellular Physiology, 1
Critical Tables, International, 155
Crozier, W. J., Protozoan Fauna of Sewage Filter, 424
Crude Rubber Survey, H. N. Whitford, 282
Cunningham, B., North Carolina Academy of Sciences, 497

Dall, W. H., T. Tolmachoff and C. E. M. Fischer, Water Glass as Mounting Medium, 396
Daniel Giraud Elliot Medal, 82
Darwinism and Mr. Bryan, 82
Daturas affected by Mosaic Injury, E. E. Stanford and E. D. Davy, 450
Davenport, C. B., University of Tennessee and Professor Schaeffer, 86; Congress of Eugenics, 143
Davy, E. D., and E. E. Stanford, Daturas affected by Mosaic Injury, 450
Donnan Equilibrium, G. S. Adair, 13
Duane, W., and G. L. Clark, Abnormal Reflections of Crystals, 400
Dumble, E. T., Marine Wilcox in Mexico, 31
Dunn, G., Building of National Academy of Sciences, 298
Dyes, British, 206

East, E. M., Mankind at the Cross-roads, W. S. Thompson, 445
Eclipse, of September 10, 62, 223; Expedition Insurance, 175
Ecological Society of America, A. G. Vestal, 357
Edgar, G., Inorganic and Theoretical Chemistry, J. W. Mellor, 249; American Chemical Society, 309
Education, Engineering, Study of, 417
Ehrenfeld, A. A., Ancient Reference to Airships, 179
Eigenmann, C. H., Andes in Northern Peru, 532
Einstein, Theory, R. Trumpler, 161; Foucault and Soldner, T. J. J. See, 372; L. P. Eisenhart, 516; Confirmation of, 517
Eisenhart, L. P., Einstein and Soldner, 516; Relativity and Modern Physics, G. D. Birkhoff, 539
Electrical Structure of Matter, E. Rutherford, 209
Electro-chemistry, Organic, 175
Electrolysis, Active Hydrogen by, A. C. Grubb, 371
Elliot Medal, Awards of, 88, 488
Ellis, M. M., and W. H. Eyster, Effects of Insulin and Glucokinin on Maize Seedlings, 541
Engineering Education, 417
Environment, Relation of Species to, W. D. Hoyt, 432
Epinephrin, F. A. Hartman, 74
Essig, E. O., Pacific Slope Branch American Association of Economic Entomologists, 354
Esterly, C. O., Western Society of Naturalists, 356
Eugenics, Genetics and the Family, C. B. Davenport, 143; In Race and State, S. J. Holmes, 144
Experimental Data, Statistical Significance of, Edwin B. Wilson, 93
Eyster, W. H., and M. M. Ellis, Insulin and Glucokinin and Maize Seedlings, 541
Ezekiel, W. N., Hydrogen Ion Concentration and Sclerotinia Apothecia, 166

Fasten, N., Pacific Fisheries Society, 355
Feldman, H. W., Recessive Black Variety of Roof Rat, 163
Femoral Deformation, G. E. Rhoades, 305
Ferris, G. F., Entomological Illustrations, 265
Finland, Experiment Stations in, 415
Fischer, C. E. M., W. H. Dall and T. Tolmachoff, Water Glass as Mounting Medium, 396
Fisher, A., Mathematical Theory of Probabilities, R. Pearl, 51
Fishes fallen from the Sky, W. Jochelson, 516
Fisk, H. W., Magnetic Declination, D. L. Hazard, 123
Fletcher, Alice C., F. LaFlesche, 115
Fluorescence, F. E. Lloyd, 91, 229
"Foliar Ray," Significance of the, R. E. Torrey, 304
Forbes, A., Physico-Chemical Basis of Psychic Phenomena, 48
Forbes, A. W., Question of Rhetoric, 121; Selection of Subjects for Research, 493
Forest Reserves of State of New York, 344
Formaldehyde and Vitamin Content of Milk, A. M. Bleile and R. J. Seymour, 518
Fossil Field in Mongolia, 156
French Association for Advancement of Science, 117
Frost, W. S., Quantitative Analysis, 256

Gels and Theory of Adsorption, N. E. Gordon, 495
Gericke, W. F., Adaptation of Wheat, 17
Germann, F. E. E., and M. C. Hylan, Dispersity of Silver Halides, 332
Germany, Needs of Scientific Men in, J. P. C. Southall, 246; Scientific men of, and Research, F. C. Newcombe, 397
Getman, F. H., J. Willard Gibbs and his contribution to Chemistry, 129
Giles, A. W., Earth Evolution and its Facial Expression, W. H. Hobbs, 86
Godman and Salvin Memorial, 157
Goldfarb, W. J., Medical Sciences at Cincinnati, 514
Goldsmith, W. M., Laws of Life, D. S. Jordan, 207
Gonzalez, L. F., History of National Culture of Costa Rica, P. P. Calvert, 71
Gordon, N. E., Gels and Theory of Adsorption, 495
Gorgas Memorial Institute of Tropical and Preventive Medicine, 221
Goto, S., T. Inamuru and D. S. Jordan, Japanese earthquake, 492
Greek, Modern and Classical, A. McAdie, 372
Greenwood, Major, Medical Research, 133
Grier, N. M., Streams of Long Island, 86
Grubb, A. C., Active Hydrogen by Electrolysis, 371
Gruenberg, B. C., Asymmetrical Oratory, 35
Gudger, E. W., Capture of Whale Shark, 180
Guinea Pigs, Parthenogenetic Development of Eggs in, L. Loeb, 35; Brown-Séquard's Epilepsy in, J. Auer, 109, 183
Gulick, John Thomas, D. S. Jordan, 509

Haematoxylin, C. E. McClung, 515
Hail, A. Bevan, 443

HALL, E. H., Arthur Gordon Webster, 37
HARSHBERGER, J. W., Forest Distribution in Northern Rocky Mountains, J. E. Kirkwood, 266
HARTMAN, F. M., Production of Epinephrin, 73
Harvard College Observatory, 301
HATT, W. K., Research Committees, 195
HAWKINS, L. A., and W. R. WHITNEY, Industrial and Academic Laboratories, 179
Hazard, D. L., Magnetic Declination, H. W. FISK, 123
HEALD, F. D., Northwest Scientific Association, 391
Heat Transfer, Symposium on, 416
Helium Atom, Model of, R. DEL. KRONIG, 537
Hemoglobin and Certain Gases, T. HOUGH, 465
HENDERSON, A., Size of the Universe, 167
Herbert Davis Forestry Farm, 242
Histamine and Gastric Secretion, A. C. IVY, G. B. MCILVAIN and A. J. JAVOIS, 286
HITCHCOCK, H., Sodiro Herbarium, 465
HOBBS, W. H., Life of Sir Ernest Shackleton, H. R. Mill, 33; Second Pan-Pacific Science Congress, 342
Hobbs, W. H., Earth Evolution, A. W. GILES, 86
HOFFMAN, F. L., Program of Section K, at Cincinnati, 260
HORN, D. W., Medical Licensure of Non-Medical Doctors, 79, 286
Horse Flesh, Use of, C. F. LANGWORTHY, 120
HOUGH, T., Hemoglobin and Certain Gases, 465
HOYT, W. D., Relation of Species to Environment, 432
HRDLIČKA, A., Paleontological Finds in Moravia, 63
HUBBS, C. L., Classification of Fishes, D. S. Jordan, 181
HUXLEY, J. S., Late Fertilization and Sex Ratio in Trout, 291
HYLAN, M. C., and F. E. E. GERMANN, Dispersity of Silver Halides, 332

Illustrations, Entomological, G. F. FERRIS, 265
Imperial Institute, 487
INAMURU, T., S. GOTO and D. S. JORDAN, Japanese Earthquake, 492
Industry and Chemical Research, 306
INMAN, O. L., Iron-depositing Bacteria, 13
Insurance for Eclipse Expedition, 175
Iowa Academy of Science, J. H. LEES, 126, 146
Iron-depositing Bacteria, O. L. INMAN, 13
IVY, A. C., G. B. MCILVAIN and A. J. JAVOIS, Gastric Secretion and Histamine, 286

Japanese Earthquake, S. GOTO, T. INAMURU and D. S. JORDAN, 492
JAVOIS, A. J., A. C. IVY and G. B. MCILVAIN, Gastric Secretion and Histamine, 286
JEFFREY, E. C., Structure and Origin of Coking Coals, 285
JOCHELSON, W., Fishes Fallen from the Sky, 516
JOFFE, J. S., and H. C. MCLEAN, Alkali Soils, 52
Jordan, D. S., Classification of Fishes, C. L. HUBBS, 181
JORDAN, D. S., Laws of Life, W. M. Goldsmith, 207; Tunnies and Albacores, 227; S. GOTO and T. INAMURU, Japanese Earthquake, 492; John Thomas Gulick, 509
JUDAY, C., Copepod in Finger Lakes, N. Y., 205

KAHN, M., Jacob Rosenbloom, 436
KARRER, E., Applied and Pure Science, 10
KEEN, W. W., Memories of 60 years, 121
KELLEY, A. P., Subsoil Acidity, 36
KELLOGG, V., Relief for Russian Scientists, 264; Work of National Research Council, 337, 362; Psychic Life of Insects, E. L. Bouvier, 423
Kentucky Academy of Science, A. M. PETER, 184
Keynes, J. M., Probabilities, R. PEARL, 51
KING, H. D., Black-eyed Yellow Mutation in Rats, 250
Kirkwood, J. E., Forest Distribution, J. W. HARSHBERGER, 266
KNIBBS, G. H., Science and its Service to Man, 453
KRONIG, R. DEL., Model of Helium Atom, 537
KUNZ, G. F., Mineralogie de Madagascar, A. Lacroix, 373

Laboratories, Industrial and Academic, W. R. WHITNEY and L. A. HAWKINS, 179
LAFLEISCHE, F., Alice C. Fletcher, 115
Lake States Forest Experiment Station, E. G. CHENEY, 175, 200
LANE, A. C., Temperature of Mines, 141
LANGMUIR, I., Positive Ion Currents from Positive columns of Mercury Arcs, 290; Photo-electric Effects, 398
LANGWORTHY, C. F., Horse Flesh, Use of, 120
Laue Photographs, X-rays in, R. W. G. WYCKOFF, 52
LEE, F. W., and F. C., Rotating Magnetic Field and Growth, 352
LEES, J. H., Iowa Academy of Science, 146
Lefevre, George, 198
LEHMER, D. N., Charles Newton Little, 299
Leidy, Joseph, Centenary, 11, 461
LEWIS, E. P., Contributions of Astronomy to Civilization, 405
LEWIS, I. F., Union of American Biological Societies, 257
LIGHT, S. F., Amphioxus Fisheries near University of Amoy, 57
Limnaea, Coiling in, A. H. STURTEVANT, 269
Lithium Spectrum, Spark Line in, F. L. MOHLER, 468
Little, Charles Newton, D. N. LEHMER, 299
LIVINGSTON, B. E., Philological Sciences, 42; Blackened Spheres for Atmometry, 182; The Cincinnati Meeting, 485
LLOYD, F. E., Fluorescence in Cyanophyceae and Diatomaceae, 91; Ultramicroscopically Observable Fluorescence, 229
LOCHHEAD, A. G., Agricultural Bacteriology, F. Löhnis, 306
LOEB, L., Parthenogenetic Development of Eggs in Ovary of Guinea Pigs, 35
Longevity in Spores, A. MCCREA, 426
Long Island, Streams of, N. M. GRIER, 86
Luminescence, Committee on, E. L. N., 229
LYMAN, T., Photographic Plates for Extreme Ultra-Violet, 48

MCADIE, A., The Air and Its Ways, N. Shaw, 87; "A Hundred Pounds," 141; Atmospheric Pollution, Report on, 330; Modern and Classical Greek, 372
MCBAIN, J. W., Chemistry and Modern Life, 429
MCCLINTOCK, J. A., Transmission of Nematode Resistance in Peach, 466
MCCLUNG, C. E., Haematoxylin, 515
MCCREA, A., Longevity in Spores of Aspergillus Oryzae and Rhizopus Nigricans, 426
McDougall, W., Outline of Psychology, H. C. WARREN, 70.
MCILVAIN, G. B., A. C. IVY and A. J. JAVOIS, Stimulation of Gastric Secretion by Histamine, 286
MCLENNAN, J. C., Quantum Theory, 253
MCMURRICH, J. P., A Retrospect, 521
Magnetic Field of the Earth, L. A. BAUER, 113
MAHIN, E. G., Educational Value of Study of Quantitative Analysis, 317
Maize Seedlings, Effects of Insulin and Glucokinin on, M. M. ELLIS and W. H. EYSTER, 541
Mammals, Marine, Conservation of, E. W. NELSON, 135; Sex Chromosomes of, T. S. PAINTER, 247
MARCOVITCH, S., Plant Lice and Light Exposure, 538
Marine Biology at Trieste, 9; at Woods Hole, 142
MARTIN, J. C., and J. S. BURD, Phosphate Behavior in Soils, 227
Massachusetts College of Pharmacy, 467
Mathematics, Society of America, R. G. D. RICHARDSON, 380, 520; Association of America, W. D. CAIRNS, 392
Matter, Electrical Structure of, E. RUTHERFORD, 209

MATTHEW, W. D., Grundzüge der Paläeontologie, 107
MAVOR, J. W., X-Rays and Crossing-over, 124
Maxwell, S. S., Labyrinth and Equilibrium, F. H. PIKE, 398
Medical, Progress, 32; Licensure of Non-Medical Doctors, D. W. HORN, 79, 286; Research, M. GREENWOOD, 133; Students, Number of, 174; Research, 181; Contract Practice in England, 351; Research in India, 373; Progress, Friends of, T. BARBOUR, 507; Sciences at Cincinnati, W. J. GOLDFARB, 512; Association, British, Australasian Congress of, 259
Medicine, Fellowships in, 102; of National Research Council in, 200
Meisinger, C. L., Free Air Pressure Maps, C. F. BROOKS, 122
Mellor, J. W., Inorganic and Theoretical Chemistry, G. EDGAR, 249
Mercury Arcs, Positive Ion Currents from Positive Column of, I. LANGMUIR, 290
Meteorological, American, Society, E. A. BEALS, 335
Methylen Blue, Certified, H. J. CONN, 41
Microscope Users, Warning to, W. F. ALLEN, 445
Milbank Memorial Fund, 437
Mill, H. R., Life of Sir Ernest Shackleton, W. H. HOBBS, 33
MILLER, G. A., Mathematics, D. E. Smith, 288
MILLIKAN, R. A., Science and Society, 293
Minervals, 397
Mines, Bureau of, Scientific Appointments of, 64; Temperature of, A. C. LANE, 142
MIURA, K., On Function of Cerebellum, 361
MOHLER, F. L., Evidence of Spark Line in Lithium Spectrum, 468
Mongolia, Fossil Field in, 156
MOODIE, R. L., Pachyostosis, 351
Moravia, Paleontological Finds in, A. HRDLIČKA, 63
Morley, Edward Williams, Cup, 460
MORSE, E. S., Agassiz and School at Penikese, 273
MULLIKEN, R. S., Band Spectra of Boron Nitride, 164
Museum, Natural History, Educational Value of University, F. C. BAKER, 55; Annual Report of British, 81
Museums, New Era for American, L. V. COLEMAN, 172

National, Research Council, F. R. LILLIE, 63, 200, V. KELLOGG, 337, 362, 489, 533; Academy of Sciences, G. DUNN, 298; W. W. CAMPBELL, 324, 427; Geographic Society, 460; Parks, 532
Naturalists, American Society of, A. F. SHULL, 392
NELSON, E. W., Conservation of Marine Mammals, 135
NEWCOMBE, F. C., German Scientific Men and Research, 397
New England Intercollegiate Geological Excursion, 344
New Hampshire Academy of Science, W. C. O'KANE, 230
NEWTON, W., Rest Period of Solanum Tuberosum, 207
New York State Forests, W. G. VAN NAME, 444; Forest Reserves of State of, 344; Zoological Society, Tropical Research Station of, H. F. OSBORN, 60
NICHOLS, J. T., Transition Zones, 153
Nobel Prize in Physics, Awards of, 461
NOBLE, G. K., Voice in Mating Batrachians, 270
Nopsca, F. B., Fortschritte der Geologie und Paleontologie, E. C. CASE, 517
North Carolina Academy of Science, B. CUNNINGHAM, 497
Northwest Scientific Association, F. D. HEALD, 391

Oceanography, Institute of, 44
Ohio Academy of Science, E. L. RICE, 251
O'KANE, W. C., New Hampshire Academy of Science, 230
Optical Society of America, 10, 242, I. G. PRIEST, 451
Oratory, Asymmetrical, B. C. GRUENBERG, 32
Ornithologists' Union, American, 260
OSBORN, H. F., Tropical Research Station, 60

Pachyostosis, R. L. MOODIE, 351
Pacific, Coast, Entomological Society, H. E. BURKE, 354; Division of Plant Physiological Section of Botanical Society of America, G. B. RIGG, 354; Fisheries Society, N. FASTEN, 355; Science Congress, Resolutions Adoped at Australian Meeting of, 502; Slope Branch American Association of Economic Entomlogists, E. O. ESSIG, 354
PAINTER, T. S., Sex Chromosomes of Mammals, 247
Paleontological, Finds in Moravia, A. HRDLIČKA, 63; Society, Pacific Branch, C. STOCK, 357
Pan-Pacific Science Congress, W. H. HOBBS, 342
PARSONS, C. L., American Chemical Society, 271
Pasteur's Contributions to Medicine and Humanity, W. S. THAYER and P. VALLERY-RADOT, 475
Patents, International, 510
PAWLOW, I. P., Conditioned Reflexes, 359
Pawlow, I. P., Visit to America of, 45
Peabody Museum at Yale University, 7
Peach, Transmission of Nematode Resistance in, J. A. MCCLINTOCK, 466
PEARL, R., Mathematical Theory of Probabilities, A. Fisher, 51; Probabilities, J. M. Keynes, 51
PEARSE, A. S., Adventure, Romance and Science, 75
Penikese School, Fiftieth Anniversary of, 138
Pennsylvania, Power Survey of, 511
Peripatus in New Zealand, D. STONER, 341
PETER, A. M., Kentucky Academy of Science, 184
Petroleum Geologists, American Association of, M. W. BALL, 27
Phenomena, Psychic, Physico-Chemical Basis of, A. FORBES, 49
Philosophy, Science and, in Virgil, J. WRIGHT, 152; in America, F. H. PIKE, 349
Phosphate Behavior in Soils, J. S. BURD and J. C. MARTIN, 227
Photo-electric Effects, I. LANGMUIR, 398
Photographic Sensitivity, S. E. SHEPPARD and E. P. WIGHTMAN, 89
Physical Society, American, D. L. WEBSTER, 336
Physics as a Career, G. W. STEWART, 275
Physiology, Cellular, Reticular Apparatus of Golgi in, E. V. COWDRY, 1; International Congress of, 26, 116
Phytopathological Society, R. E. STONE, 208
Pieters, A. J., Aquatic Plants, 286
Pigeons, Sex Determination in, F. E. CHIDESTER, 422
PIKE, F. H., Apples, Worms, Philosophers and Goats, 349; Labyrinth and Equilibrium, S. S. MAXWELL, 398
Plant Lice and Light Exposure, S. MARCOVITCH, 538
Potential-Gradient, Atmospheric, L. A. BAUER, 67
Pound, Standard, S. RUSSELL, 69; A. MCADIE, 142
PRANG, M. D. H., Color Hearing, 421
PRIEST, I. G., Optical Society of America, 451
Priestley Medal, 248
Professor and his Wages, P. SLOSSON, 140, 444; F. R. WELSH, 330
Protozoan Fauna of Sewage Filter, W. J. CROZIER, 424
Psychology, International Congress of, 26
Public Health Association, American, 199, 367
Pulpwood Resources of Canada, 156

Quantitative Analysis, W. S. FROST, 256; Educational Value of, Study of, E. G. MAHIN, 317
Quantum Theory, J. C. MCLENNAN, 253
Quotations, 14, 32, 50, 92, 109, 121, 142, 162, 181, 206, 248, 266, 287, 306, 351, 397, 422, 467, 517

Ramsay, Memorial Fellowships, 116
Rats, Roof, Recessive Black Variety of, H. W. FELDMAN, 163; Black-eyed Mutation in, H. D. KING, 250; Stock, Ration for, H. STEENBOCK, 449
Reclamation Service, Removal of Director of, 26, 164
RENSHAW, R. R., American Chemical Society, Division of Organic Chemistry, 469
Reprints, Filing, E. G. BORING, 329; E. F. SMITH, 395

Research, and Education, W. J. YOUNG, 14; Scientific, Rewards for, 50; as a Profession, 92; Selection of Subjects for, E. C. BINGHAM, 100; Medical, M. GREENWOOD, 133; Physiological, in America, H. SEWALL, 187; Committees, W. K. HATT, 195; Council of State College of Washington, 259; Medical, in India, 373; Grants in Support of, R. M. YERKES, 434; British Agricultural, 435; A. W. FORBES, 493; Scientific and Industrial, 494; Agricultural, Administration of, E. W. ALLEN, 499
Rhetoric of Scientists, A. W. FORBES, 121
RHOADES, G. E., Femoral Deformation, 305
RICE, E. L., Ohio Academy of Science, 251
RICE, E. W., JR., Charles Proteus Steinmetz, 388
RIGG, G. B., The Botanical Society of America, 354
RICHARDSON, R. G. D., American Mathematical Society, 380, 520
ROBBINS, W. J., Poisonous Action of Castor Bean, 305
Rockefeller, Institute for Medical Research, 10; Foundation, International Health Board of, 300
Roosevelt Wild Life Forest Experiment Station, 222
Root Growth and Oxygen, W. A. CANNON, 331
Rosenbloom, Jacob, M. KAHN, 435
Ross Institute, 163
Rotating Magnetic Field, and Growth, F. W. LEE and F. C. LEE, 352
Rothamsted Experimental Station, 415
Royal Society, Medalists of, 534
Rubber, Explorations for, 103
RUEDEMANN, R., Silurian of Maryland, 34
RUSSELL, S., Standard Pound, 68; Unity of English Weights, 442
Russia, Biological Institutes in, W. J. FOX, 63; Scientists in, Relief for, V. KELLOGG, 264
RUTHERFORD, E., Electrical Structure of Matter, 209

Salisbury, Rollin D. Memorial, 417, 489
Samoa, British Expedition to, 436
San Juan County, Utah, Exploration of, 242
Santa Barbara Skull, E. H. SELLARDS, 538
SARGEANT, W. W., Los Angeles Meeting of American Association, 23, 117, 138, 333
SCHAEFFER, A. A., Marine Laboratory at Tortugas, 161
Science, Applied and Pure, E. KARRER, 19; Applied, M. BENTLEY, 69; Adventure, Romance and, A. S. PEARSE, 75; Influence of, on History and Civilization, A. SILVERMAN, 102; and Philosophy in Virgil, J. WRIGHT, 152; and Publicity, 266; Course in General, A. J. TIEJE, 278; in the Making, 287; and Society, R. A. MILLIKAN, 293; and Service to Man, G. H. KNIBBS, 453
Scientific, Notes and News, 11, 28, 46, 65, 82, 104, 118, 138, 158, 176, 201, 225, 243, 261, 283, 302, 328, 345, 393, 417, 438, 462, 489, 512, 535; Research, Rewards for, 50; Work in Siberia, 103; Work, Cooperation in, 258; Work, Recognition of, 422; Meetings, Attendance at, 437
Scorpions in North Dakota, R. L. WEBSTER, 248
SEE, T. J. J., Soldner, Foucault and Einstein, 372
Seeds and Tubers of Aquatic Plants, A. J. PIETERS, 286
Seismological Society of America, S. D. TOWNLEY, 404, 416
SELLARDS, E. H., Santa Barbara Skull, 538
SEWALL, H., Physiological Research in America, 187
SEYMOUR, R. J., and A. M. BLEILE, Effect of Formaldehyde upon Vitamin Content of Milk, 518
Shark, Whale, Capture of, E. W. GUDGER, 180
Shaw, N., The Air and its Ways, A. MCADIE, 88
SHEPPARD, S. E., and E. P. WIGHTMAN, Theory of Photographic Sensitivity, 89; A. P. TRIVELLI and E. P. WIGHTMAN, Silver Halides, 469
SHULL, C. A., Multiple Seeded Burs of Xanthium, 145
Siberia, Scientific Work in, 103
SIEVERS, F. X. J., Organic Matter in Soils, 78
Sigma Xi, H. B. WARD, 372
Silliman Lectures at Yale University, 459
Silurian of Maryland, R. RUEDEMANN, 34
Silver Halides, Dispersity of, F. E. E. GERMANN and M. C. HYLAN, 332; E. P. WIGHTMAN, A. P. H. TRIVELLI and S. E. SHEPPARD, 469
SLOSSON, P., Professor and his Wages, 140, 444
Smith, D. E., Mathematics, G. A. MILLER, 288
SMITH, E. F., Filing Reprints, 396
Sodiro Herbarium, A. S. HITCHCOCK, 465
Soil Management and Plant Nutrition, Western Society of, A. E. VINSON, 353
Soils, Alkali, J. S. JOFFE and H. C. MCLEAN, 53; Maintenance of Organic Matter in, F. J. SIEVERS, 78
Solanum Tuberosum, Rest Period of, W. NEWTON, 207
Sound, Absolute Measurements of, A. G. WEBSTER, 149
SOUTHALL, J. P. C., Needs of German Scientific Men, 247
Spores, Longevity in, A. MCCREA, 426
Standardization, Industrial, 199; International Conference on, 136
Standards, Bureau of, Physico-Chemical, at Brussels, 81; Dictionary of Specifications of, 137; Explosion at, 300
STANFORD, E. E., and E. D. DAVY, Daturas affected by Mosaic Injury, 450
Statistics, English, Vital, 488
Stecker, H., Freeman, 458
STEENBOCK, H., Ration for Stock Rats, 449
Steinhart Aquarium, Dedication of, 368
Steinmetz, Charles Proteus, E. W. RICE, JR., 388
STEWART, G. W., Physics as a Career, 275
STILES, C. W., Zoological Nomenclature, 88
STOCK, C., Pacific Branch of the American Paleontological Society, 357
STONE, R. E., Canadian Branch of American Phytopathological Society, 208
STONER, D., Collecting Peripatus in New Zealand, 341
STRAUS, W. L., Thyroid Cultures of Paramecia, 205
Students, Number of Medical, 174
STURTEVANT, A. H., Inheritance of Coiling in Limnaea, 269
Subsoil Acidity, A. P. KELLEY, 36
Sun's Gravitational Field, Light Deflection in, R. TRUMPLER, 161
Svedberg, Dr., Award to, 45

TAYLOR, C. V., Effect of the Removal of the Micronucleus, 308
THAYER, W. S., and P. VALLERY-RADOT, Pasteur's Contributions to Medicine and Humanity, 475
Thiselton-Dyer, Sir William, 157
THOMPSON, K. O., Delonza Tate Wilson, 343
THOMPSON, W. S., Mankind at the Crossroads, E. M. East, 445
Thorndike, L., History of Magic and Experimental Science, J. WRIGHT, 15
Thorndike Memorial Laboratory of Boston City Hospital, 392
Thresher Shark, Behavior of, W. E. ALLEN, 31
Thyroid Cultures of Paramecia, W. L. STRAUS, 205
TIEJE, A. J., Course in General Science, 278
TOLMACHOFF, T., W. H. DALL and C. E. M. FISCHER, Water Glass as Mounting Medium, 396
TORREY, R. E., Significance of the "Foliar Ray," 304
Tortugas, Marine Laboratory at, A. A. SCHAEFFER, 160
TOWNLEY, S. D., Seismological Society of America, 404
Transformations, Organic Chemical, L. A. BIGELOW, and K. R. BOYES, 446
Transition Zones, J. T. NICHOLS, 153
Transportation Institute Lectures, 511
TRIVELLI, A. P. H., E. P. WIGHTMAN and S. E. SHEPPARD, Silver Halides, 469
Tropical Diseases in Samoa, Expedition for Study of, 326
Trout, Late Fertilization in, J. S. HUXLEY, 291
TRUMPLER, R., Light Deflection in Sun's Gravitational Field, 161

Trust, British National, 14
Tuberculosis, Mortality from, 510
Tunnies and Albacores, D. S. JORDAN, 227

Ultra-violet, Photographic Plates for Extreme, T. LYMAN, 48
Universe, Our Knowledge of, R. G. AITKEN, 381; Size of, A. HENDERSON, 167
University, and Educational Notes, 12, 30, 48, 67, 85, 106, 119, 140, 160, 179, 203, 226, 246, 264, 285, 304, 329, 348, 395, 419, 441, 464, 491, 514, 536; Natural History Museum, Educational Value of, F. C. BAKER, 55; of Pennsylvania, Moore School of Engineering at, 81; of Tennessee and Professor Schaeffer, C. B. DAVENPORT, 86; of California, Appointments in Agriculture at, 103; of Arkansas, Deanship of College of Agriculture of, 280; of California, Fire at, W. W. CAMPBELL, 348; of Pittsburgh, Seminar on Contemporary Chemists at, 367; of California, College of Dentistry of, 437

Vacuum Pump, C. C. CHEN, 18
VAN NAME, W. G., New York State Forests, 444
VESTAL, A. G., Ecological Society of America, 357
VINSON, A. E., Western Society of Soil Management and Plant Nutrition, 353
Virgil, Science and Philosophy in, J. WRIGHT, 152
"Vitamin A" Deficiency in Poultry, J. R. BEACH, 542
Von Zittel, K. A., Grundzüge der Paläontologie, W. D. MATTHEW, 107

WALKER, M., American Chemical Society, 404
Wallace, Alfred Russel, Memorial Portrait of, 25
WARD, H. B., Sigma Xi, 352
WARD, R. de C., World Weather, H. H. Clayton, 267
WARREN, H. C., Outline of Psychology, W. McDougall, 70
Water Glass for Mounting, D. T. BURK, 13; W. H. DALL, T. TOLMACHOFF and C. E. M. FISCHER, 396
WEBSTER, A. G., Absolute Measurements of Sound, 149
Webster, Arthur Gordon, E. H. HALL, 37
WEBSTER, R. L., Scorpions in North Dakota, 248
Weed, Definition of, E. G. CAMPBELL, 50
Weights, English, Unity of, S. RUSSELL, 442
WELSH, F. R., Professor and His Wages, 330
WERTHEIM, E., Reactions of Carbon Disulphide with Aldehydes, 494
Western Society of Soil Management and Plant Nutrition, A. E. VINSON, 353; Society of Naturalists, C. O. ESTERLY, 356
Western Society of Naturalists, C. O. ESTERLY, 356
Wheat, Adaptation to Growth Media, W. F. GERICKE, 17; Yield in England, M. WHITNEY, 320
WHITNEY, M., Yield of Wheat in England, 320
WHITNEY, W. R., and L. A. HAWKINS, Industrial and Academic Laboratories, 179
Wiedersheim, Robert, H. H. W., 412
WIGHTMAN, E. P., A. P. H. TRIVELLI and S. E. SHEPPARD, Silver Halides, 469
Wilcox, Marine, in Mexico, E. T. DUMBLE, 31
Wild Plants, Conservation of, R. C. BENEDICT, 39
Wilson, Delonza Tate, K. O. THOMPSON, 343
WILSON, E. B., Statistical Significance of Experimental Data, 93
Wisent, Preservation of, T. G. AHRENS, 107
WOODWARD, W. C., Medicine and Related Arts in Chemical Laboratories, 204
World's Dairy Congress, 222
WRIGHT, J., History of Magic and Experimental Science, L. Thorndike, 15; Science and Philosophy in Virgil, 152
WYCKOFF, R. W. G., Anomalous Reflection of X-Rays in Laue Photographs, 52
WYLIE, R. G., Section G at Cincinnati, 345

Xanthium, Multiple Seeded Burs of, C. A. SHULL, 145
X-Rays, in Laue Photographs, R. W. G. WYCKOFF, 52; and Crossing-over, J. W. MAVOR and H. K. SVENSON, 124; Abnormal Reflection, G. L. CLARK and W. DUANE, 400

Yale University, Peabody Museum at, 7; Honorary Degrees at, 10; Silliman Lectures at, 459
YERKES, R. M., Grants for Research, 434
YOUNG, W. J., Staff Organization of Institutions of Research and Education, 14

ZANETTI, J. E., International Union of Pure and Applied Chemistry, 239
Zoological Record, 25; Nomenclature, C. W. STILES, 88, 422
Zoologists, Society of, W. C. ALLEE, 368
Zoology, Modern, J. H. ASHWORTH, 231

VOL.

The S
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VOL. LVIII JULY 6, 1923 No. 1488

CONTENTS

The Significance of the Internal Reticular Apparatus of Golgi in Cellular Physiology: DR. E. V. COWDRY 1

The New Peabody Museum at Yale University 7

Scientific Events:

Trieste and Marine Biology; The Liverpool Meeting of the British Association for the Advancement of Science; The Optical Society of America; The Rockefeller Institute for Medical Research; Honorary Degrees at Yale University; Joseph Leidy Commemorative Meeting 9

Scientific Notes and News 11

University and Educational Notes 12

Discussion and Correspondence:

On the Donnan Equilibrium and the Equation of Gibbs: DR. G. S. ADAIR. *Iron-depositing Bacteria:* O. L. INMAN. *Water Glass as a Mounting Medium:* DEAN T. BURK. *Staff Organization of Institutions of Research and Education:* DR. W. J. YOUNG 13

Quotations:

The British National Trust 14

Scientific Books:

Thorndike's History of Magic and Experimental Science: DR. JONATHAN WRIGHT 15

Special Articles:

On the Adaptation of Wheat to Growth Media deficient in Nutrients: PROFESSOR W. F. GERICKE. *A New Vacuum Pump:* C. C. CHEN 17

Science News vii

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THE SIGNIFICANCE OF THE INTERNAL RETICULAR APPARATUS OF GOLGI IN CELLULAR PHYSIOLOGY[1]

IT is natural for us to attempt to reduce physiological activities to a cellular basis. The cells of which we are composed are in a very real sense vital units. Some of them continue to survive many hours after death, and, while we live, many of them are continually dying. But we ought not be disappointed if examination under very high powers of the microscope fails to reveal any definite structural groundwork in the cytoplasm. That it is not homogeneous, as it often appears to be, does not require proof, for chemical and physical homogeneity would be inconsistent with physiological activity. We must have some faith in things unseen; we must extend our conceptions to include the morphology of the ultramicroscopic and invisible; otherwise we fail.

Like a great factory, the cytoplasm must be spacially organized for the separation and integration of chemical reactions. Industries are coordinated through trade; the cells by the blood stream. But the cell is many times more efficient than any factory. Within its small compass it rapidly brings about chemical changes which are only possible outside the body at high temperature and with the aid of much complicated machinery. It is marvelously well regulated and works with wonderful harmony. The analogy is, of course, hopelessly inadequate, but it is nevertheless useful for our purpose. As in a factory, certain areas of the cytoplasm are set apart to perform specific duties. I have in mind, for example, the contractile portion of the muscle cell and the secretory pole of the gland cell. The most recently recognized area and the one about which we know the least appears in many cases to be of fluid nature. It has been called the Golgi apparatus after its discoverer, but the term "apparatus" is unfortunate because it suggests a mechanism of a rather inanimate type. With the dawn of an era of experimentation in technique, much attention is being paid to this portion of the cytoplasm. Already the literature has become so unwieldy that to save valuable time we gladly avail ourselves of carefully constructed reviews, like those of Duesberg, Cajal and Pappenheimer, to determine what has or has not

[1] Eighth Harvey Lecture delivered at the Academy of Medicine, New York, March 19, 1923.

been done. It is indeed a striking commentary upon the domination and apparent self-sufficiency of classical methods of cytological analysis that this cytoplasmic constituent, which frequently occupies an area as large as the nucleus, should have remained almost unnoticed for so long.

(1) *Morphology:* As a result of the discovery that the apparatus is argentophile after certain fixatives (Golgi) and that it may be blackened by prolonged treatment with 2 per cent. osmic acid (Kopsch), many facts have come to us regarding its shape. In the somatic cells of mammals and the majority of vertebrates it is usually encountered in the form of a more or less dense network consisting of anastomosing strands of uneven girth but of smooth outlines. It may be closely drawn together into a rather compact mass, or dispersed throughout the cytoplasm in isolated fragments, as is often the case in nerve cells. It is never of exactly the same morphology even in neighboring cells of the same kind, which indicates great ability and has given rise to the belief that it may be changing in shape from moment to moment.

In attempting to understand changes in form, we have to be on our guard, because slight variations in technique may result in networks which are either unusually robust or else thin and anemic looking or in the complete disintegration of the apparatus into droplets of irregular size. But well-controlled preparations do show conclusively that the shape of the apparatus is in a general way typical of different cell types. For instance, its appearance is quite characteristic in acinus cells of the pancreas and polymorphonuclear leucocytes—in the one it is a large network of coarse meshes located between the nucleus and the lumen, in the other it is a small rather dense mass to be found in the cytoplasm in the concavity of the nucleus. Furthermore, if glands like the submaxillary and thyroid are examined in several different groups of animals the same general style of Golgi apparatus is repeatedly met with. In other words, variations in its morphology are probably very closely related to variations in cellular organization and function.

In the lower metazoa, the information at hand appears to show that generally speaking the Golgi apparatus is rather prone to occur in disconnected fragments, instead of in the form of complicated networks. Particularly is this true in stages of oogenesis and spermatogenesis. Isolated masses are also to be detected in the protozoa. To this circumstance is due the practice of some authors in speaking of Golgi "bodies." The word "body" unavoidably carries the impression of distinctive form and to some extent of solidity as contrasted with relative fluidity.

(2) *Occurrence:* Material resembling the typical Golgi apparatus, as it was first described in the nerve cells of mammals, is of very wide occurrence. If we search through the cells of the human body we find it present in each and every one except in those which are dead and dying, like non-nucleated red blood cells and desquamating epidermal cells. Not only does a Golgi apparatus occur in all embryonic cells, but with growth and differentiation, it undergoes a definite sequence of changes, suggesting, as pointed out by Bensley, that we have to do with a material which behaves as a unit in the developmental cycle. In the phylogenetic series we are confronted by a similar condition of affairs. It is safe to say that a Golgi apparatus or its representative has been seen in all vertebrates which have been properly examined, also in many invertebrates, and in plants (Laburu and others.) In establishing homologies, however, it is necessary to keep before us the fact that we are actually dealing with mixtures of unknown substances which vary in density as compared with the ground substance, so that as yet we are only permitted to outline the probable distribution of the Golgi apparatus, with due qualifications and in the most tentative way. Borderline cases are perplexing because the properties of the material unquestionably vary progressively in the life history of specialized cells so that it is difficult to say when we are dealing with a true Golgi apparatus or with substances which may be in part its products—an uncertainty which is also encountered in dealing with mitochondria. With our present technique we may just skim the surface and recognize a few of its most general attributes. When, after further experimentation, we are able to examine it more closely, with really refined methods, it is quite possible that we shall find distinctive variations in cells of different categories. As in other biological problems, so also here a close study of morphology and behavior must precede chemical and physiological analysis.

In our analogy of the factory, it is like the discovery of the existence in all manufacturing plants the world over of rather pretentious buildings, characterized by certain distinctive architectural features and built of materials almost wholly unknown to us.

(3) *Size:* Some cells are evidently fitted to perform their duties with a large Golgi apparatus (gland cells) and others with a relatively small one (muscle cells). We know also that the Golgi apparatus is usually well developed in the active stages of cytomorphosis, that it becomes gradually smaller as the cell ages (except in plants) until it finally disappears with senility and death. There is also satisfactory evidence to the effect that this peculiar cytoplasmic area becomes enlarged in certain pathological conditions. For instance, Tello discovered a marked degree of hypertrophy in tumors of the mammary gland and his results are in harmony with an increase

in the size of the apparatus which Da Fano subsequently noticed in the mammary gland during pregnancy and lactation. Other instances might be cited, but we shall do well to err if anything upon the side of conservatism in recording experimental changes and to accept only alterations which are very pronounced, because slight variations in size occasionally occur spontaneously without apparent rhyme or reason. Some of them may be due to slips in technique or to the influence of changes in light or temperature upon the silver reaction or the blackening with osmium. For the present an accurate quantitative determination of the Golgi apparatus is beset with almost insurmountable difficulties. Nobody has yet attempted to establish a definite Golgi apparatus—cytoplasmic ratio on the basis of relative volumes. We cannot even say, with confidence, whether the material is present in relatively larger amounts in protozoa or in man.

Passing now to a consideration of the actual mechanism of changes in size we at once plead complete ignorance. There has, however, been no dearth of speculation. On cell division the networks are broken up into smaller masses (resembling perhaps the Golgi "bodies" of lower forms) which are distributed approximately equally to the two daughter cells, in which the networks are again reconstituted. Sometimes this process is characterized by great regularity; at other times it has the appearance of being rather haphazard. Attempts have not been wanting to bring the so-called "Golgi bodies" into line with other cytoplasmic components, especially the plastids of plants, which are, at least in some cases, self-perpetuating and multiply by direct division without loss of their individuality. Gatenby in particular has come out squarely with the declaration that "both mitochondria and Golgi bodies are able to assimilate, grow and divide in the cytoplasm somewhat as a protist assimilates, grows and divides in a watery medium." By this he does not intend to imply that they are symbiotic organisms. He wishes only to indicate that they possess a marked degree of independence. He is not alone in this contention, but the idea of the individuality of chemical substances, expressed in relation to the Golgi apparatus, in a system which is itself a coordinate whole, does not make a strong appeal to those of us who have been chiefly occupied with the somatic cells of vertebrates in which the networks frequently attain to a high degree of complexity and in which they often undergo hypertrophy without preliminary fragmentation into small aggregates. Under these circumstances, growth by some process of accretion seems more likely to prevail.

(4) *Position*: Another point of interest, and we trust of immediate practical importance, is that the Golgi apparatus appears to move about in the cytoplasm in a remarkable and orderly manner. In cells of fixed secretory polarity, like the acinus cells of the pancreas, which have already been mentioned, and the cells of the salivary glands, it is always placed between the nucleus and the discharging pole. In the thyroid, on the other hand, I have found that, at least in the adult guinea pig, it normally migrates from one end of the cell to the other. That is to say, from its usual position between the nucleus and the lumen it may approach the lumen or flow around the nucleus to the opposite end of the cell adjacent to the peripheral vascular network. This reversal may take place in entire follicles or within single cells. There seems to be a kind of ebb and flow. In order to view this phenomenon in true perspective, we may recall that the position of the Golgi apparatus is subject to great variation in the cells of the choroid plexus, studied by Biondi, and that a somewhat similar but progressive change in its position has been noted by Golgi in mucus-secreting intestinal epithelial cells.

Since we have reason to believe that the thyroid differs from other glands like the pancreas in being able, under conditions which are but little known, to pour its secretion directly into the peripheral vascular network, I made the suggestion, in January of last year (1922), that we have in these migrations a real indicator of physiologic reversals in polarity. If this theory is confirmed experimentally, preparations of this type revealing the position of the Golgi apparatus will afford accurate information regarding the direction of secretion at the time the tissues are taken. In this way it may well be possible to effect a close correlation between the actual discharge of thyroid secretion and the response by the organism to its action. I also suggested that an examination of the Golgi apparatus in the parathyroids and the hypophysis, in both of which intracellular secretion antecedents remain to be discovered, might yield clues regarding the direction of discharge, but preparations were made of these tissues from adult guinea pigs without my being able to discover any definite orientation on the part of the apparatus.

But the probability of success with the thyroid is clearly indicated by Masson's paper on the position of the centrosomes in malignant thyroid tumors published last June (1922). It has been abundantly shown that the centrosomes are often closely related in a topographic sense to the Golgi apparatus. Like the Golgi apparatus they usually occur in thyroid cells between the nuclei and the lumen. But in tumor cells Masson found them to migrate in the direction of the peripheral blood vessels. In one of his illustrations it may be seen that, though most of them are in the usual position, a few are reversed. In another, all are reversed and the colloid has disappeared from

the lumen and has accumulated about the peripheral blood vessels. The follicles seem to have been turned completely inside out in respect to the direction of secretion. Successful preparations of the Golgi apparatus would probably have revealed the same phenomenon.

Last April, Courrier and Reiss published a short note dealing with the position of the Golgi apparatus in the parathyroids of new-born kittens. With the apparatus as an indicator, they claim to have established the existence of a definite secretory polarity and the presence of a network of capillaries of two types. They believe that at this stage the cells are arranged in cylindrical columns, the surfaces of which are bathed by nutritive capillaries and the central areas drained by others of excretory nature, and that the position of the Golgi apparatus between the nucleus and the central capillary indicates the existence of a definite functional polarity. The authors point out that this discovery of polarity opens up a somewhat new conception of endocrine cells, it having been customary thus far to deny the presence of definite secretory polarity in all of them except the thyroid. They call attention, for example, to Van der Stricht's claim that the lutein cells may secrete from any point of their surface—*i.e.*, that they are apolar—and to the fact that Colson is of the same opinion in respect to the cortical cells of the suprarenals. Now the possibility is raised that other cells, in addition to those of the parathyroids, may be definitely polarized. This information supplied by Courrier and Reiss, if confirmed, may be useful in helping us to find true secretion antecedents in the parathyroids. When we know the pole of the cell from which the secretion is discharged, we shall at least know where the antecedents are likely to be most concentrated.

In a second paper published in June, Reiss made a study of the position of the Golgi apparatus in the secretory cells of the anterior lobe of the cat's hypophysis. What he found is indeed most striking. As a preliminary to the discussion he remarks that, from the work of Stewart and others, it seems likely that the three types of cells with which we have to deal are closely related. From being chromophobe, they become basophile and then acidophile. In the first named, the apparatus is, according to Reiss, without special orientation which corresponds nicely with the view that these cells are resting. In the basophile cells it is invariably found between the nucleus and the periphery of the cluster, and finally in the acidophiles it is located between the nucleus and the central area. Reiss claims to have observed all transitional stages in this sequence. His interpretation is that we have a mechanism by which the cells are able in one stage to pour a secretion toward the periphery and then to turn about face and discharge a second and different product into the center of the cluster. It is questionable whether these suggested oscillations in secretory polarity could have been detected without the clue offered by the migration of a conspicuous structure like the Golgi apparatus. We naturally await confirmation of Reiss's work with some eagerness.

A significant observation to be emphasized is that reversal in the position of the Golgi apparatus may also be induced experimentally in tissues in which it does not occur normally. D'Agata discovered a change in position in epithelial cells of the newt's stomach following scarification, and Basile found that it could be reversed in the cells of the straight and convoluted tubules in one kidney through the extirpation of the other. From its normal position between the nucleus and the lumen it migrates to the opposite pole facing the peripheral blood-vessels. Unhappily, these observations have not been confirmed, but the illustrations presented by Basile are so clear and convincing that it is difficult to imagine how he could have gone astray. But we must not be premature and hasten to the conclusion that the purpose of the Golgi apparatus is to elaborate secretion, because we find it to be equally highly developed in nerve cells and in others in which secretory activities are not pronounced. Neither can we say that in gland cells it is wholly unrelated to the formation of secretion, since so marvelous an integrating and unifying principle is manifest in all vital processes. We have to steer a middle course. What the observations which I have related do show is that we are now able to follow significant changes in the position of an important and hitherto unrecognized cytoplasmic area. From the technical point of view we are on firmer ground than in the study of variations in the shape and size of the Golgi apparatus, inasmuch as it is altogether unlikely that any error in manipulation would constantly bring about so definite a shifting in the relative position of parts of the cytoplasm.

To return again for a moment to our confessedly inadequate analogy of factory organization, it is as if the above-mentioned large and unknown buildings, presumably containing machinery vital to the industry, were found to be capable of undergoing periodic migrations to the other end of the lot.

(5) *Constitution:* Thus far stress has been placed upon objective findings which are subject to verification. Unfortunately, any logical and comprehensive interpretation which will fit all the facts is a thousandfold more difficult. We are not even justified at this time in hazarding speculations as to what is going on within this newly discovered region of the cell, although several investigators have not shown any reluctance to express their views on the subject. It has already been intimated that while our methods

are so crude we can not exclude the possibility that under the same heading we are grouping a variety of formations. The affinity of the Golgi apparatus for silver salts after appropriate fixation has been mentioned and the ease with which it may be blackened by prolonged immersion in osmic acid. It may occasionally be stained with iron hematoxylin and resorcin fuchsin. Either it or one or more of its components are soluble in alcohol, for unless preparations are dehydrated very promptly no trace of it remains. It has been repeatedly asserted that the Golgi apparatus is at least partly of lipoidal nature. According to Gatenby, it has in this respect much in common with mitochondria. Bowen is of the opinion that the Golgi bodies observed in insect spermatogenesis are made up of two components, one staining darkly and the other lightly—an idea which has been elaborated by subsequent investigators, but I see no good reason to suppose that the Golgi apparatus in the somatic cells of higher vertebrates is heterogeneous in the same sense.

The chief obstacle is that the Golgi apparatus can not be clearly seen in living unstained cells examined in approximately isotonic media—to be specific in mammalian tissues, because several workers claim to have observed Golgi bodies in the living cells of certain invertebrates. Nor has it been possible to stain the material with vital dyes, although many have been tried. This small branch of cytology has in fact advanced about as far as did our knowledge of mitochondria before the introduction of janus green. At that time there were many "doubting Thomases" who have since been converted. We hope and expect a similar development in the case of the Golgi apparatus. But in fairness we are obliged to admit that, as revealed to us in fixed preparations upon which we must for the moment rely, it is an artefact in the sense that it conveys an impression which does not fully or accurately represent the condition of affairs in the living cell. We suspect that the dense black outlines give rise to a false idea of relative solidity for the reason that when cells are carefully crushed under the microscope it may be seen that the mitochondria and other granules have freedom of motion and that they are not impeded by the presence of a semi-rigid network in the area which we know to be occupied by the Golgi apparatus. I have found, moreover, in the thyroid that it is by no means a simple matter to displace the Golgi apparatus by centrifugation, from which it is safe to deduce that it is, in the tissue examined, of about the same specific gravity as the remainder of the cytoplasm.

(6) *Reactions to injury:* It was soon shown by Cajal and other investigators that the Golgi apparatus is very sensitive to autolytic influences. In nerve cells removed from the body it loses, within a very few minutes, its distinctive net-like form and breaks up into a very fine dust-like deposit. The sequence of alterations following experimental injury to nerve cells has been the subject of several papers first by Marcora and later by Cajal and Penfield. As a result, the apparatus becomes dispersed into the peripheral cytoplasm and finally disappears completely. In phosphorus poisoning I have noted a corresponding fragmentation but no peripheral migration. It is a singular fact that unlike the mitochondria (W. J. M. Scott) the Golgi apparatus takes little or no part in the ensuing fatty degeneration.

The time at my disposal forbids reference to further work along this line except to make the general comment that investigators in biology and medicine have not been slow to grasp the fact that the Golgi apparatus offers an entirely new criterion of cell injury, the study of which may yield surprising results of far-reaching importance. It is to be regretted that the problems involved have not always been approached in a spirit likely to bring adequate returns. In recent years cytology has become a very highly specialized science and must be treated with due respect. Nobody would launch forth upon a complicated chemical analysis without adequate training in chemistry. Disappointment would follow as surely as day follows night. The instances are exactly parallel. No matter how detailed are the instructions, a technician can not be expected of his own initiative to follow them successfully and to arrange for suitable controls. The investigator himself must buckle right down to work, and prepare himself for some disappointments, if he is to reap the reward. In a study so delicate it is even within the bounds of possibility that trained individuals looking eagerly for some distinctive changes will all unconsciously be influenced to report some deviation from the normal, especially when the normal is not readily established, as in the case of human tissues removed at operation or at autopsy. It is open to serious question whether the study of mitochondria has not also suffered grievously from the hastily planned and ill-considered observations of investigators who are masters in their own fields and have simply been attracted by the shimmer of something which is strange and new.

(7) *Relation to the so-called canalicular apparatus:* Before concluding this address, brief mention should be made to a kind of evidence which we apprehend only dimly but which seems to shed some light upon the nature of the materials which we have under consideration. About the time that Golgi announced his discovery (1898), Holmgren and other workers found a system of clear canals within the cytoplasm of a large variety of cells belonging to the same categories in which the presence of the Golgi

apparatus was being reported. They were seen after many fixatives, but especially trichlorlactic acid, and exhibited the property of remaining uncolored when the rest of the cytoplasm was stained. Their close resemblance in form and position to the apparatus of Golgi attracted widespread attention, so much so that Cajal was led to propose the name of Golgi-Holmgren canals to include both formations. This action, however, has not pased unchallenged. Duesberg has reacted strongly against its unqualified acceptance. He is of the opinion that the two formations are identical in neurons and non-nervous cells which possess a localized trophospongium (canalicular system) but that in non-nervous cells with a diffuse trophospongium spread throughout the cytoplasm they can not be the same because the Golgi apparatus is restricted to one pole of the nucleus.

We note also that Penfield has found distinctive changes in the morphology and position of the Golgi apparatus in nerve cells after section of the posterior nerve roots. And, further, that when the same cells were bleached and stained with iron hematoxylin he was able to observe a system of clear canals in the cytoplasm which in no way corresponded with the remnants of the Golgi apparatus. He naturally concluded that the clear canals and the blackened Golgi apparatus are two entirely different formations. These observations merit very careful consideration. A close examination of his figures shows that the clear canals which he found are not exactly the same as the canalicular apparatus in normal nerve cells. The canals are angular and to some extent suggestive of shrinkage spaces; they are abundant in the peripheral cytoplasm and in some cases appear as if they might penetrate into the cell from without; whereas in normal cells of the same kind the canalicular apparatus presents rounded contours and is usually situated in the intermediate zone of the cell, leaving a layer of cytoplasm immediately about the nucleus and just beneath the cell membrane clear. This may mean that we are dealing with a canalicular apparatus distinctively changed by section of the nerve roots or that we are confronted by an altogether different type of tubular system.

It is, I think, significant that von Bergen discovered in certain nerve cells shreds of blackened material within clear canals—an observation which has led investigators to infer that the clear canals contain a fluid which is argentophile, osmophile, soluble in alcohol and exhibits all the properties which we are accustomed to refer to the Golgi apparatus. Though I have been unable to repeat this observation of von Bergen, I have obtained similar but less striking information pointing in the same direction. In nerve cells the clear canals, like the blackened apparatus, may be diffuse, eccentric or circumnuclear in position after fixation in formalin, trichlorlactic acid and osmic acid. The same three morphologic types are seen after staining with Weigert's hematoxylin. What appear to be transitions may be detected between clear canals and aggregates stainable with resorcin-fuchsin, and also between clear canals and osmic acid-blackened masses. In other words, in both instances there seems to be a progressive increase of the stained material at the expense of the clear canals. My preparations suggest positive and negative impressions of one and the same thing. In the pancreas I have bleached out the blackened networks and find in all cases a corresponding system of clear canals remaining, although the size of the cells is altered by the repeated hydration and dehydration. But it is unsafe to go as far as to claim that the clear canals and the blackened reticula occurring in all cells are visible expressions of the reactivity of one and the same cytoplasmic area.

We know that clear, chromophobe spaces in the cytoplasm are not always of the same origin. They may represent areas from which the mitochondria have been dissolved; instead of being restricted to a definite location they may be experimentally produced throughout the cytoplasmic area; in some cases pointed clefts which are apparently technical artefacts may be continuous with a canalicular apparatus in its proper location. And these are not the only possibilities that complicate the problem. Repeated attempts on my part to make clear canals artificially in mixtures of gelatin and lecithin, fixed by methods designed to reveal the canalicular apparatus, have not been particularly fruitful. Preparations made in this way and stained with iron hematoxylin contain canals and vacuoles of many sizes. By careful selection, however, it is possible to gather together a series of canals which resemble to some degree the intracellular formations which so perplex us. That intracellular canals are not always fixation artefacts may be concluded from Bensley's observation that they may be seen in living islet cells of the pancreas. But the mere act of taking living cells from the body and of bringing them under the microscope for study may, and probably does, initiate changes in the cytoplasm which may be wholly or in part responsible for the appearances in question.

The same investigator made a parallel study of the clear canals in plant and animal cells by improved methods of technique. Through the study of both living and fixed tissues he found a very significant series of changes in growing cells of the onion tip. In the youngest cells he discovered a system of clear canals, agreeing in many details with those brought to light by the same methods in animal cells. With increase in age the canals enlarged and finally gave rise to the familiar plant cell vacuole. On the basis

of these observations he suggested "that the network of canals found in so many animal cells is the physiologic and morphologic equivalent of the vacuolar system in the plant cell." This far-reaching generalization has recently (1922) received support from the botanists, Guilliermond and Mangenot. These investigators worked with barley cells and arrived at a similar conclusion by employing methods adapted to the demonstration of the Golgi apparatus in animal cells. If further work shows that this is in truth the case, interesting and new opportunities for experimental study will be opened up of a kind essentially different from those contingent upon the discovery of the nucleus.

To come back to the starting point in our discussion of what we are pleased to call "cellular organization" which is, after all, the central problem of physiology, it is as if an inhabitant of Mars observed one of our large manufacturing plants with a powerful telescope and discovered a large and conspicuous building, and, further, that he noted similar buildings in other centers the world over, capable of changes in size and shape and of migration from place to place. It would be only natural for him to try to discover what mysterious activities go on within them. This is what we are endeavoring to do with the Golgi apparatus in animal cells. At present we see through a glass darkly, but we hope that this haziness is merely the rather invigorating cloud of mystery which usually surrounds a new development in science. We do not like to think that we are only hot in the pursuit of a phantom.

E. V. COWDRY
THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH
NEW YORK

THE NEW PEABODY MUSEUM AT YALE UNIVERSITY

THE corner-stone of the new Peabody Museum at Yale University was laid on June 18. President Angell presided, and Professor Edward S. Dana, Yale '70, chairman of the museum trustees, and curator of the mineralogical collection since 1874, laid the corner-stone. Professor Richard S. Lull, director of the museum and curator of vertebrate paleontology, spoke of the present work and future plans of the museum staff. Professor Dana referred to the fact that seven years had elapsed since the trustees agreed to surrender the old museum site in order to make possible the erection of the Memorial Quadrangle. The former Peabody Museum, opened in 1876, cost about $175,000; the new building will cost about $900,000.

Our chief duty and pleasure to-day, said Mr. Dana, is to honor the generous gentlemen who gave the original sum for our Museum of Natural History, Mr. George Peabody; also Professor Othniel C. Marsh, who collected and studied the specimens which make our collections unique; also the many other gentlemen who have worked loyally with him and since his death.

Mr. Peabody, born in Danvers, Massachusetts, in 1795, a poor boy at the start, by his own efforts and sagacity amassed a large fortune, and of this he gave away about ten million dollars before his death in 1869—an enormous sum for that time. His gifts were so numerous that no attempt can be made to enumerate them here. First in magnitude and importance was the gift of one and three quarter millions for the housing of the poor of London. This generous act was so fully appreciated in England, where Mr. Peabody spent the larger part of his life, that Queen Victoria warmly acknowledged it, and presented Mr. Peabody with a miniature of herself surrounded by diamonds and pearls. But this was only one of Mr. Peabody's generous donations. To the city of Baltimore he gave one million dollars; to the South he gave two millions and a half to assist in popular education without distinction of race or color; to many other cities and institutions he gave also most liberally. The gifts, however, which concern us to-day are those of one hundred and fifty thousand dollars each to Yale for a Museum of Natural History, and to Harvard for a Museum of American Archeology.

The Peabody Museum will always be associated with the name of Professor Othniel Charles Marsh. Not only was the fact of his being a nephew of Mr. Peabody, an important element in our securing the gift mentioned of $150,000, but by his keen scientific knowledge and by his collecting, begun even before his first expedition with students of the College in 1870, he amassed an amount of material in vertebrate paleontology that is absolutely unique. In the early years the West was an unexplored region, the localities where the fossil remains existed had never been disturbed, and much of the material had been weathered out by nature entire or in part, so that the minimum amount of labor was required for its collection. Tons of invaluable specimens in thousands of boxes came from the West, and when Professor Marsh died in 1899, the Marsh Collections were of such extent that even now with numerous assistants at work, much of the material is still to be developed. It would be a graceful thing to mention the names of his helpers, but time does not permit. Collecting and study are still going on under the supervision of the director, Professor R. S. Lull, and hardly a month passes that papers are not published on the Marsh collections. This last work is aided by the Marsh Publication Fund, $30,000 and more, left in his will primarily to complete some of the volumes he had begun or had in his mind. This particular use of the money was found to be impracticable, however, be-

cause the volumes were not far enough advanced to make it possible for others to go on with the work except on an independent basis—hence the establishment of this sum as a special fund to be used for the working out and description of the Marsh material. It is indeed fitting that the main hall of the new building in the plans as now matured should be devoted to the exhibition of the more striking of the remarkable extinct animals in the Marsh Collection. Some of them are bizarre in appearance or very large in form. The *Brontosaurus,* for example, of which we have a practically perfect skeleton, measures sixty-seven feet in length. The *Stegosaurus* and *Claosaurus* are other of our gigantic reptiles; they are the relatives of those of the Connecticut River Valley which made the so-called bird tracks of which we also have a very large collection. The work of installing the specimens, begun by Professor Marsh, carried on by Professors Beecher, Schuchert, Lull and others, has been a great enterprise, even now continued under the generous roof of the Osborn Laboratories.

The Zoological Collection is also remarkably complete and fine, especially in the marine life of our Atlantic and Pacific shores. This we owe most of all to the ceaseless labors of Professor A. E. Verrill, also simultaneously of Professor Sydney I. Smith, and recently of Professors W. R. Coe and R. G. Harrison. Professor Verrill's long connection with the work of the United States Fish Commission was invaluable to us. It would require far more time than is available now to give any adequate idea of the labors of Professor Verrill, a student of the great Louis Agassiz in the sixties, and an indefatigable worker from the beginning even to the present time, when he carries a number of years that would crush most men.

The mineral collection, a very prominent part of the treasures in the "Old Cabinet Building" on the Yale College campus, which disappeared long ago, was transferred to the museum in 1876, and has grown steadily since that time till it was packed up and moved. Every specimen was out of the building by May, 1917. This collection, with many additions not yet exhibited, will be installed in this building by the new curator, Professor W. E. Ford.

The archeological collection was also begun by Professor Marsh. It has been added to largely by the present active curator, Professor George Grant MacCurdy. It is now of great value and extent.

Professor Lull spoke in part as follows:

During this period the zoological collections have been carefully inspected, renewed and classified, and many new preparations, both of individual specimens and of habitat groups, have been carried to completion in anticipation of the new halls which they are to grace.

The department of geology, really paleontology, has been yet more active in proportion to its larger staff. About fourteen hundred out of some forty-five hundred trays of fossil vertebrates, containing many thousands of specimens in varying degree of preparation and repair, have passed through the hands of the preparators, and are for the first time entirely conditioned for exhibition, study, systematic storage or exchange. Group after group of creatures thus prepared have been catalogued and monographed, so that, aside from its present accessibility due to our more complete knowledge of its contents, the scientific data which the collection has yielded have been made the subject matter of more than one hundred technical papers, which have appeared or are ready for publication. In addition seven skeletons of pre-historic animals of moderate size have been mounted, some of them embodying original ideas of technique as yet unattempted elsewhere.

The invertebrate collections have been likewise reworked to as large an extent as time and the available labor permitted, and have been also the source of scientific enlightenment to the world. During the disembodied period the collection has increased by purchase, expedition and gift, some of the results of which filled sorely felt gaps in our study and especially our exhibition series. I can mention only the collection of Permian insects—which, excepting Sellard's, probably equally large, is the greatest in the world—gathered by Professor Dunbar; the materials illustrating European pre-history assembled by Professor MacCurdy; the beautiful collection of American Indian relics made by Colonel Charles H. Bigelow and given by Mrs. Bigelow; the Yale Peruvian collection presented through Director Bingham; and lastly, because of its supreme importance, the marvelous collection of the heads and skins of the vanishing great mammals of the world, presented by Mr. Thomas Cardeza.

A year should see the completion of this fabric with its nine halls for exhibition, in which the collections will be most carefully installed in such a way that he who visits them can view the orderliness and continuity of Nature and observe for himself the results of what Henry Van Dyke calls the "Divine Law of Evolution." These halls will be used not alone by Yale students, although as a university museum the chief aim is for their teaching, but the other duty to the city is not lost sight of, for New Haven has no civic museums, save that of the New Haven Colony Historical Society, as have many of the other cities of the world, but relies on the university collections to aid in the dissemination of truth to her people. A direct appeal will be made to the visiting public, but more especially to the young citizens of our public schools.

SCIENTIFIC EVENTS

TRIESTE AND MARINE BIOLOGY

DR. M. STENTA, director of the Natural History Museum in Trieste, delivered an address, in October, 1921, at the Trieste meeting of the Italian Society for the Advancement of Science, on the part played by Trieste in the study of marine biology. The address has recently been published and is abstracted in *Nature*, from which we quote.

Dr. Stenta referred to the observations of Abbot Fortis published in 1771 on the islands of the Quarnero, and those of Abbot Olivi (1792), who gave, in his "Zoologia Adriatica," a catalogue of the animals of the Gulf of Venice. Almost all the naturalists who visited Trieste in the first half of last century were German; of these, two may be named: I. L. C. Gravenhorst, who recorded (1831) the results of his studies on various molluscs, echinoderms and Anthozoa; and J. G. F. Will, who gave an account (1844) of the anatomy of Scyphozoa, ctenophores and siphonophores. K. E. von Baer came in 1845 from Russia to Trieste to search for larvae of echinoderms, but the results in that and in the following year were not very satisfactory. His visit, however, was fruitful in another respect, for he encouraged Koch, a young Swiss merchant resident in Trieste and an ardent collector, in his project of founding a museum of the Adriatic fauna, which became the center of studies on the Gulf of Venice. Johannes Müller spent the autumn of 1850 in Trieste working on the development of echinoderms and worms.

Among many who worked at the museum between 1850 and 1870 were Oscar Schmidt, who carried on researches on sponges; A. E. Grube, who examined the annelids and discovered the parasitic rotifer *Seison nebaliae*; and Kowalevsky, who described (1868) the remarkable sexual dimorphism in *Bonellia viridis*. In 1874 the Adriatic Society of Natural Science was founded and the 27 volumes of its bulletin are rich in observations on the biology of the area.

In 1875 the Institute of Marine Biology was established by the Austrian Government, and many famous naturalists have worked in its laboratories, *e.g.*, Metchnikoff, on intracellular digestion and phagocytosis; Kowalevsky, on medusae; Driesch, on the development of isolated blastomeres; the brothers Hertwig, F. E. Schultze, K. Grobben and Hatschek.

In 1900 the zoological station was enlarged and reorganized under the new director, Professor C. I. Cori. A list of the more important investigations carried on at the laboratory from that time until 1915 is given by Dr. Stenta, including Friedländer's investigation of the constitution of the purple secretion of Murex, for which 14,000 specimens were collected; Heider's work on the development of Balanoglossus, and Przibram's researches on regeneration in Crustacea. There were also several investigations in applied zoology; the culture of sponges, the coral fishery, and parasitic protozoa of fishes.

It appears from the concluding part of the address that the Italian Royal Committee for Marine Investigation, which took over the zoological stations at Trieste and Rovigno, proposes to suppress the former, and Dr. Stenta puts forward a plea for its retention.

LIVERPOOL MEETING OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

A PRELIMINARY program of the Liverpool meeting of the British Association, to be held from September 12 to 19, under the presidency of Sir Ernest Rutherford, has been issued. The railway companies have agreed to supply return tickets at a single fare and a third to all members who obtain vouchers from the offices of the association, at Burlington House. The president is to deliver his address at the opening meeting on the first evening, taking as his subject the "Electrical Structure of Matter." He will probably be able to describe recent work in the experimental transmutation of elements.

In accordance with the innovation made since the war, the thirteen addresses of the sectional presidents are to be distributed over the week, five being given on the Thursday, five on Friday, and three on Monday. In these the applied side of science is to be given full scope, Professor Ashworth discussing the bearing of zoology on human welfare; Dr. Vaughan Cornish, the opportunity of the British Empire; Dr. Crowther, science and the agricultural crisis; Sir H. Fowler, science and transport; Mr. C. Burt, the mental differences of individuals with special reference to industry; and Sir William Beveridge, employment and population. The presidents of the geological, physiological, botanical, chemical and mathematical sections are to deal with pure science. Professor Nunn is to discuss the education of the masses, and Professor Newberry is to devote his address to Egypt as a field for anthropological research.

The two most important discussions are to be held by the physicists, chemists and engineers on cohesion and molecular forces, and by the chemists and physiologists on the physical chemistry of membranes and its relation to human physiology. There will be a discussion on the origin of domestic animals by geographers and anthropologists.

The Lord Mayor of Liverpool is to give a reception on the Thursday evening, on Friday evening Professor Elliot Smith is to lecture on the study of man, and on the Tuesday evening there is to be a scientific soirée. The more important industrial works in or near Liverpool are to give opportunities to members

to inspect them and excursions of a varied nature are being arranged.

THE OPTICAL SOCIETY OF AMERICA

THE Eighth Annual Meeting of the Optical Society of America will be held at Cleveland, Ohio, October 25, 26 and 27, 1923. The regular sessions for the reading of papers will be open to all interested persons.

Members and others desiring to communicate results of optical research are invited to submit titles of papers for the program to the secretary any time before September 10. Titles received after that date can not be included in the program. There will be no "supplementary program." Each title must be accompanied by an abstract ready for publication. These abstracts will be printed in the program and in the minutes of the meeting. The purpose of the abstract is to give: (1) A more definite description of the *nature* and *scope* of the paper than can be conveyed in the title; (2) the essential results in so far as may be possible in the limited space allowed. It is hoped that the advance publication of these abstracts will prepare those attending the meeting to consider the papers more intelligently and with much greater interest. Printed forms on which to submit titles and abstracts may be obtained on application to the secretary. Inasmuch as their use will greatly simplify and expedite the work of editing and printing the program, the secretary earnestly requests that these forms be used in submitting abstracts.

Attention is invited to the following resolution adopted by the council at its annual meeting, October, 1922: "That it is the sense of the council that ordinarily members should not present, without invitation, papers which have already been published."

No title will be printed to be presented "by title." Titles should not be submitted unless the author has a *bona fide* intention to actually present the paper orally or have it presented by some one else.

The Committee on Papers for the Cleveland Meeting consists of Herbert E. Ives, *Chairman,* W. E. Forsythe, H. G. Gale, Irwin G. Priest and Charles Sheard.

IRWIN G. PRIEST,
Secretary.

BUREAU OF STANDARDS,
WASHINGTON, D. C.

THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH

THE Board of Scientific Directors of The Rockefeller Institute for Medical Research announces the following promotions and appointments:

Dr. Oswald T. Avery, Dr. Walter A. Jacobs, Dr. Michael Heidelberger, Dr. Christen Lundsgaard, Dr. Peter K. Olitsky and Dr. Louise Pearce, hitherto associates have been made associate members. Dr. David I. Hitchcock, Dr. Frederic M. Nicholson, Dr. Henry S. Simms and Dr. Leslie T. Webster, hitherto assistants have been made associates. Dr. Mimosa H. Pfaltz, hitherto a fellow, has been made an assistant.

The following new appointments are announced:

Associate Members	Dr. Jacob J. Bronfenbrenner
	Dr. Paul A. Lewis
Associates	Dr. Oskar Baudisch
	Mr. Herbert L. J. Haller
	Dr. Stuart Mudd
Assistants	Mr. Arnold M. Collins
	Dr. John H. Crawford
	Dr. Robert Elman
	Dr. Joseph H. B. Grant
	Mr. Moses Kunitz
	Dr. Cecil D. Murray
	Dr. Everett S. Sanderson
	Dr. David T. Smith
	Mr. James Vander Scheer
	Dr. Lars A. Welo
Fellows	Miss Gladys Bryant
	Dr. Charles Korb
	Miss Dorothy Loomis
	Dr. Elmer L. Straub

Dr. J. Howard Brown, hitherto an associate in the department of animal pathology, has accepted a position as associate professor of bacteriology with Johns Hopkins Medical School.

Dr. Fred A. Taylor, hitherto an associate in chemistry, has accepted a position as head of the department of bio-chemistry at the William H. Singer Memorial Research Laboratory, Pittsburgh, Pa.

HONORARY DEGREES AT YALE UNIVERSITY

IN presenting candidates for honorary degrees at Yale University, Professor William Lyon Phelps said of those on whom the doctorate of science were conferred:

WALTER BRADFORD CANNON: Physiologist. Dr. Cannon was born in Wisconsin, is a graduate of Harvard and professor of physiology. He is a fellow of many scientific societies at home and abroad. His war services were conspicuous. He was president of the Medical Research Society of the American Red Cross in France in 1917–18, and lieutenant-colonel of the Medical Corps. He was decorated Companion of the Bath, British, in 1919. As an investigator he is in the front rank of American physiologists. His work on organic conditions as affected by emotion is profoundly original, and on it is based the diagnostic method which is now employed. When he was a medical student in 1896, he used the X-ray while studying the processes of digestion. He observed that anxiety, worry and anger were immediately registered by the stoppage of motions in the alimentary tract. He became a specialist in the relation of emo-

tional excitement to bodily disorders and has since given us scientific reasons for not worrying and for remaining cool under provocation. For nearly two years, 1917–1919, Dr. Cannon was working in France on the results of shock, and in the perfecting of the proper treatment. He is a scholar and a benefactor of mankind.

JACQUES LOEB: Head of the Department of Experimental Biology, Rockefeller Institute for Medical Research. Dr. Loeb was born in Germany, and studied medicine at Berlin and Munich, receiving the degree of doctor of medicine from Strasbourg in 1884. He is a member of many learned societies at home and abroad: The National Academy of Sciences; honorary member of the Royal Institute, corresponding member of the Institute of France, honorary member Royal Belgian Medical Academy, corresponding member Cracow Academy, the Moscow Society of Naturalists. He has been professor at Bryn Mawr, for the eagle eye of Miss Carey Thomas saw his youthful possibilities; at Chicago and at the University of California. Since 1910 he has been head of the division of general physiology, Rockefeller Institute. His publications have made him one of the foremost men of science in the world. His work on artificial parthenogenesis is nothing short of epoch-making, and his analyses of the mechanical and chemical bases of the simpler forms of animal behavior bid fair to revolutionize the fundamental conceptions of biology. An experimenter of extraordinary ingenuity, he has brought all the resources of physics and chemistry to bear on the interpretation of vital processes. His work on the dynamics of living matter has led him to profound discussions upon mechanistic philosophy. He is something more than an original investigator; he is, in every sense of the word, creative.

HENRY FAIRFIELD OSBORN: Paleontologist. Merely to enumerate the list of Dr. Osborn's achievements, services, and resulting decorations would make us late for the alumni dinner. He was graduated from Princeton in 1877: he has received the degree of doctor of science from Princeton and from Cambridge; doctor of philosophy from Christiania, and doctor of laws from Trinity, Princeton and Columbia. He was professor of comparative anatomy at Princeton, professor of biology and later research professor of zoology at Columbia, where for some years he was dean of the faculty of pure science. He is president of the American Museum of Natural History, easily the first institution of its kind in this country and undoubtedly in the front ranks of the world's great museums. He has also been president of innumerable institutions and societies in natural history, vertebrate paleontology and zoology. The range of his activities may be partly indicated by his having been president of the International Congress of Eugenics, of the American Bison Society and of a School for Girls. He is an honorary member of scientific societies in England, France, Russia, Germany, Italy, Sweden, Belgium and South America. He is not only a citizen of the world, but of all time, applying the most recent methods of study to the most ancient periods of history. His books are illuminating illustrations of the happy combination of scientific information and literary art.

JOSEPH LEIDY COMMEMORATIVE MEETING

ON December 6, 1923, the centenary of the birth of Dr. Joseph Leidy will be commemorated by several meetings to be held in the Academy of Natural Sciences of Philadelphia. The meetings will be under the auspices of the following organizations, with all of which Dr. Leidy was associated:

The Academy of Natural Sciences of Philadelphia
The American Association of Anatomists
The American Entomological Society
The American Philosophical Society
The American Society of Naturalists
The Boston Society of Natural History
The College of Physicians of Philadelphia
The National Academy of Sciences
The Smithsonian Institution
The Swarthmore College
The University of Pennsylvania
The Wagner Free Institute of Science
The Wistar Institute of Anatomy and Biology
The Zoological Society of Philadelphia

A large number of scientific organizations throughout the world have been invited to designate representatives to attend the meetings, which have been planned to suitably present the comprehensiveness of Dr. Leidy's researches.

The addresses to be delivered at the meetings will be appreciative of the diversity of Dr. Leidy's contributions to science. These have been selected as follows: General estimate of influence upon scientific thought and development; Personal recollections and appreciation as an anatomist; Zoological work; Paleontological and geological work; Botanical work; Mineralogical work; Medical work. The speakers upon these topics have been selected and their names will be announced at a later date.

As a part of the commemorative meeting there will be established a Joseph Leidy Memorial Medal, as a trust with the Academy of Natural Sciences of Philadelphia, to be awarded in recognition of preeminent contributions to the biological sciences.

A banquet at the time of the meeting has been planned, and several other features, which would aid in suitably and permanently commemorating the importance of Dr. Leidy's researches, may be arranged.

The joint committee in charge of the commemoration is composed of twenty-one representatives of the above listed organizations. An executive subcommittee of ten has immediate direction of details for the main committee. The address of the committee and executive sub-committee is, care of the Academy of Natural Sciences of Philadelphia.

SCIENTIFIC NOTES AND NEWS

SCIENCE will hereafter be printed by The Science Press Printing Company, Lancaster, Pennsylvania.

DR. DAVID WHITE, senior geologist of the United States Geological Survey and president of the Geological Society of America, received the degree of doctor of science from the University of Cincinnati on June 16, and the same degree from the University of Rochester on June 18.

BROWN UNIVERSITY has conferred its doctorate of science on Dr. George D. Birkhoff, professor of mathematics in Harvard University.

THE degree of doctor of science has been conferred by Williams College on Edward Barton, professor of sanitary chemistry at the University of Illinois.

WILLIAM BOYCE THOMPSON, of New York, president of the Roosevelt Memorial Association, who recently founded the Institute for Plant Research at Yonkers, N. Y., received the degree of doctor of laws at the commencement exercises of the University of Kentucky.

THE University of Cambridge has conferred the doctorate of science on Professor H. A. Lorentz, of Leiden, who has been lecturing in England under the auspices of the Anglo-Batavian Society.

THE University of St. Andrews will confer the honorary degree of LL.D. on Herbert William Richmond, University lecturer in mathematics in the University of Cambridge, retiring president of the London Mathematical Society, and Sir Robert Robertson, chief government chemist, London.

ON the occasion of the birthday of the King of England the following have been knighted: G. H. Knibbs, director of the Bureau of Science and Industry, of Australia; W. J. R. Simpson, professor of hygiene, King's College, London; Dr. H. W. G. Mackenzie, Royal College of Physicians, and J. Evershed, director of the Kodaikanal and Madras Observatories.

M. MOLLIARD, dean of the faculty of science of the University of Paris, has been elected a member of the Paris Academy of Sciences in the section of botany to succeed the late Gaston Bonnier.

THE Helmholtz gold medal, awarded once in ten years by an international committee for the most significant research in the domain of optics, has been given to Professor K. von Hess, of Munich, for his investigations on color vision.

THE Swedish Medical Association has founded a gold medal, called the "Gullstrand Medal," in honor of Dr. Alvar Gullstrand, professor in physiologic and physical optics at Upsala. This prize will be awarded for the first time in 1932 and thereafter each tenth year, without regard to nationality.

DR. G. N. LEWIS, of the University of California, has been elected an honorary member of the London Chemical Society.

PROFESSOR JACOB G. LIPMAN, of Rutgers College, has been elected a member of the Swedish Royal Society of Agriculture.

AT the recent meeting in Montreal of the Canadian Medical Association a resolution of thanks was passed to Dr. T. C. Banting, of Toronto, for the discovery of insulin. It was announced that the Canadian Government would be asked to offer suitable recognition of Dr. Banting's services.

A FAREWELL banquet was tendered Dr. Perry G. Snow, retiring dean of the University of Utah School of Medicine, by the students of the medical association of the university on May 24. Professor L. L. Daines acted as toastmaster. Dr. Snow, who will be succeeded as dean by Dr. Ralph O. Porter, of Logan, Utah, will make a tour of the eastern medical schools.

THE silver loving cup, given by the Detroit Local Section of The American Society of Mechanical Engineers to the Associated Technical Societies of Detroit to be presented to the winner of the civic welfare papers contest, was won by Frank Burton, commissioner of buildings and safety engineering for the city of Detroit. The prize-winning paper was on "The fundamentals of city zoning."

GEORGE A. STETSON, assistant professor of mechanical engineering at Yale University, and for the past four years editor of the *Transactions* of The American Society of Mechanical Engineers, has resigned both these positions to enter the wholesale coal business in Boston.

DR. HERMAN M. BIGGS, New York State commissioner of health, formerly professor of medicine in the University and Bellevue Hospital Medical School, died on June 28, of pneumonia, at the age of sixty-three.

UNIVERSITY AND EDUCATIONAL NOTES

THE University of Chicago has announced a gift of $200,000 from the Seymour Coman estate, the income to be used for "scientific research, with special reference to preventive medicine and the cause, prevention and cure of diseases."

AT the commencement exercises of Rensselaer Polytechnic Institute last week, the alumni association made initial plans for the celebration in October, 1924, of the centennial of the institute.

HERBERT S. HADLEY, formerly governor of Missouri, has been elected president of the University of Missouri, to succeed Dr. Frederic A. Hall.

MR. CHARLES W. PUGSLEY, of Lincoln, Nebraska, assistant secretary of agriculture, has presented his resignation to Secretary Wallace and has accepted the presidency of the South Dakota College of Agriculture and Mechanical Arts.

DR. J. HOWARD BROWN, Europa, Miss., and Dr. William L. Holman, San Francisco, have been appointed associate professors in bacteriology at Johns Hopkins Medical School, to succeed Dr. Stanhope Bayne-Jones, who resigned to become head of the department of bacteriology in the University of Rochester Medical School.

DISCUSSION AND CORRESPONDENCE

ON THE DONNAN EQUILIBRIUM AND THE EQUATION OF GIBBS

THE theory of membrane equilibrium due to F. Donnan (1911) is exciting much attention at the present time. There is no doubt that it is one of the most important contributions to colloid chemistry, and as the work of a fellow countryman, I do not wish to diminish the praise that has been given to it. Nevertheless, it is of historical interest to find that the Donnan equilibrium is one more addition to the list of theories implicit in the work of J. Willard Gibbs, published in the transactions of the Connecticut Academy in 1875. It is remarkable that Gibbs' equation has been overlooked for more than forty years, in view of the fact that membrane equilibrium enters into so many problems.

The following quotation is taken from the 1906 edition of "The Scientific Papers of J. Willard Gibbs," Vol. 1, p. 83:

> We will, however, observe that if the components S_1, S_2, etc., can pass the diaphragm simultaneously in the proportions a_1, a_2, we shall have for one particular condition of equilibrium
>
> $a_1 m_1' + a_2 m_2' + \text{etc.} = a_1 m_1'' + a_2 m_2'' + \text{etc.} \ldots\ldots$" (78)
>
> a_1 = equivalent weight of substance S_1
> a_2 = equivalent weight of substance S_2
> $m_1' = m_2'$ are the potentials of S_1, S_2 inside the membrane
> $m_1' = m_2''$ are the potentials of S_1, S_2 outside the membrane
>
> If S_1, S_2 behave like perfect gases, equation (78) can be simplified since $dm_1 =$ at. d. log p_1 (285)
> where t is the temperature and p the pressure
>
> $$\log p_1' + \log p_2'' = \log p_1'' + \log p_2''$$
>
> expressing concentrations in the conventional manner this becomes
>
> $$[S_1]' \times [S_2]'' = [S_1]'' \times [S_2]''$$
>
> Equation (78) applies to solutions of electrolytes which do not obey the gas laws, but we have stated this simple form of it for comparison with Donnan's equation:
>
> $$[Na]' \times [Cl]' = [Na]'' \times [Cl]''$$

G. S. ADAIR
MASSACHUSETTS GENERAL HOSPITAL
BOSTON, MASSACHUSETTS

IRON-DEPOSITING BACTERIA

THE presence of three kinds of iron-depositing bacteria (*Spirophyllum ferrugineum* Ellis, *Gallionella ferruginea* Ehrenburg, *Leptothrix ochracea* Kützing or *Chlamydothrix ochracea* Migula) in the natural chalybeate waters around Yellow Springs, Ohio, seems not to have been reported previously.

Gallionella, according to Harder,[1] has been reported in three localities in the United States, *viz.*, from mines in southwestern Wisconsin, central Minnesota and from the city water supply of Madison, Wisconsin. As found at Yellow Springs, Gallionella, as well as the other two genera mentioned above, is abundant in the water that issues to the surface in the Cedarville limestone. One of these chalybeate springs has made a large deposit of ocherous material, which gives us some indication that the deposition at this particular spring has probably been going on for a long time.

As noted by Harder[1] it is quite striking that these iron bacteria are so peculiarly distributed, their distribution sometimes seeming to depend upon the amount of iron in the water, but often on other less well-known causes. We have many springs in this vicinity and these bacteria appear in a very few of them. The causes of distribution as well as many morphological and physiological features of these iron-depositing bacteria remain unsettled.

O. L. INMAN
ANTIOCH COLLEGE

WATER GLASS AS A MOUNTING MEDIUM

THE use of the common water glass or egg preserver as a mounting medium for microscopic objects has not been reported to my knowledge. Very recently I have had occasion to use it with such apparently successful results that I am forwarding this note in the hope that others who possibly have tried it successfully or otherwise will give us the benefit of their experiences.

It is used in the same manner that one would employ with Canada balsam, but has the added advantage that dehydration is not necessary. The medium at the periphery of the cover glass quickly hardens to the consistency of glass itself, thus sealing in the liquid center in which the specimen is held. The liquid condition of the medium surrounding the specimen, while viscous enough to prevent movement,

[1] Harder, E. C., "Iron-depositing bacteria and their geologic relations," U. S. Geological Survey Professional Paper 113.

allows hairs, scales and bristles to maintain a natural position. It is not satisfactory for mounting alcoholic specimens, but those previously cleared in K O H may be mounted with the same ease that is experienced with fresh or water preparations.

It also makes a very satisfactory substitute for shellac in mounting insects on points, as it is colorless, unaffected by heat and holds the insect securely in many cases where the shellac mounted insect is apt to snap off.

DEAN T. BURK
UNIVERSITY OF CALIFORNIA

STAFF ORGANIZATION OF INSTITUTIONS OF RESEARCH AND EDUCATION

PROFESSOR WHETZEL'S letter of resignation as administrative head of the Department of Plant Pathology at Cornell University, extracts from which were printed in *Phytopathology,* xii 10, October, 1922, p. 499, ought to lead to a broad discussion of the staff organization of our institutions of research and education. There is no question that our present system is archaic, a remnant of the time when our institutions were small and each department was fully served by a single scientist or professor with perhaps the aid of an assistant whose duties were strictly those of a helper.

With the growth of our institutions there has been a natural increase in the working force of the various departments, while administrative duties have absorbed more and more of the energies of the department chief, with the result that at the present time the bulk of the research and teaching is being taken care of by persons of the nominal grade of assistant, though with a minimum of direct supervision by the department head. If the only persons concerned were those to whom the system is familiar, the matter of title would be of little consequence. The system, however, is very confusing to members of the general public, who are in the habit of interpreting the titles of professional workers in terms of their own occupation. To such persons the assistant is merely a helper, a species of apprentice who has not demonstrated the capacity for independent work, and one who remains an assistant indefinitely is looked upon as a failure in his profession. Not long ago I was discussing the merits of a certain research worker with a man of wide business experience when I was interrupted by the remark: "But he is only an assistant. He hasn't arrived." Need we marvel that men of this type are so often suspicious of the education which has been so largely imparted by the assistant professors of our colleges? Is it strange that the hard-headed business men who inhabit our legislative halls go slow in providing support for research to be carried on by apprentices? And how are we to regard the farmer who, having written for information to his state experiment station and receiving a perfectly good letter signed by an assistant, feels that his request has been slighted, loses confidence in the institution and fails to write again?

Thus it follows that young men of real ability as teachers or investigators, if they are to gain proper recognition and an adequate salary, and if they are to gratify a laudable ambition for accomplishment, are forced into commercial lines or obliged to seek administrative positions when they may have but moderate administrative talent and would be happier and more successful could they pursue the occupation of their choice. As the demand for administrators is limited, the result is discontent and frequent changes of personnel. Evidently there is a feeling abroad that the present form of organization might be improved. Many of the larger universities have established full professorships other than those occupied by administrative department heads, but this practice does not abound to as great an extent as could be wished. The appointment of associates and subsidiary research men has served as an expedient to get around the difficulty. No doubt many of the heads of our institutions would be glad to give their men greater recognition if they could do so without appearing to degrade the professional title by associating it with an inadequate salary, and there are certainly numerous departmental heads of broad enough mind to see no loss of prestige to themselves in an increased recognition of their associates. Probably reforms in these respects may best be brought about by degrees, and Professor Whetzel's suggestions, if not too strictly interpreted, have a good deal of point as a step taken by one on the inside. May we not hope that when many of the so-called assistants shall find themselves in positions of administrative authority, means may be found for further progress in organization reform?

W. J. YOUNG
OHIO AGRICULTURAL EXPERIMENT STATION

QUOTATIONS

THE BRITISH NATIONAL TRUST

YESTERDAY the National Trust added another interesting possession to its steadily growing list. Lord Ullswater accepted, on its behalf, from the Norfolk and Norwich Naturalists' Society an island of some twelve hundred acres of sand-dunes and saltings on the Norfolk coast, the protection of which has long been desired by all lovers of birds and flowers to whom it was known. Such a place finds its natural guardian in the Trust, whose work at Wicken Fen, Blakeney Point, and elsewhere has already won the

confidence of those who are alive to the importance of saving our Nature reserves before it is too late. The task of protecting such properties from the dangers which threaten them is not an easy one, even after they have been acquired, as was hinted in the account of Scolt Head given in our columns on Thursday. But the first step is their purchase, and it is satisfactory that that step has again been successfully taken and another home of wild life added to the secured treasures of the nation.

Few societies have gone more steadily forward, even during the last nine difficult years, than the National Trust. It is not yet thirty years old, but in a very short time it won such public confidence that it received special powers under its own Act of Parliament; and it has now more than a hundred properties of one kind or another. What is more remarkable is that nearly half of them have been acquired during the lean years which have followed 1913. Of course a hundred is a mere drop in the ocean of "places of natural beauty or historic interest" which it would be desirable to see in the hands of the Trust. But it is a beginning, and a beginning which has grown fast, and promises to grow still faster. The truth is that the growth of the Trust is partly the result and partly the cause of a change in public opinion. A hundred, and even fifty, years ago buildings of the greatest historic or architectural interest were destroyed, places of exceptional beauty were built over or otherwise ruined, and scarcely a voice was heard in protest. Such crimes, or follies, are still committed, though much less often; but now they never fail to arouse public indignation. The whole movement demanding the preservation of great architecture and the protection of beautiful landscape has gathered greatly increased force since the foundation of the Trust. The original Ancient Monuments Act has been largely extended: a permanent Commission on Historical Monuments has been appointed, and has already published its survey of several counties; a Society for Nature Reserves has been founded; many dioceses have established committees for the care of their churches; and the National Trust itself has become the owner of one or two large and many small historic houses, several properties having associations with such great names as those of Gray and Wolfe and Coleridge, and some thousands of acres of the most beautiful open land in the country, including a large part of the shore of Derwentwater and other properties adjoining Ullswater and Windermere. Such achievements are proof of the strength of the movement and a sure promise of its future development. *Vires acquirit eundo.* What is done to-day will be doubled to-morrow. But the need is doubling, too. Time and man are always engaged in the work of destruction, and an always increasing population is always needing more open spaces. However fast the Trust grows, it is certain that it will not, at least in our time, overtake the calls made upon it.—*The London Times.*

SCIENTIFIC BOOKS

A History of Magic and Experimental Science during the First Thirteen Centuries of our Era. By LYNN THORNDIKE, Ph.D., professor of history in Western Reserve University. Two volumes, I. xl. 835, II. vi. 1036. New York, The Macmillan Company. 1923.

PROFESSOR THORNDIKE'S book of two volumes and more than 1800 pages will easily take the lead of all that has been said of the intellectual conditions of the period of which it treats. It stretches across the centuries from the time of Pliny and Galen to the time of Dante. This is a period of depression in the history of thought in its various phases, of which several writers in this country have studied the details in notable works. To those few still active who in their younger days may have entered the subject through the fascinating pages of Draper's "Intellectual Development of Europe" and are still attracted by the subject, this product of Thorndike's labor will be especially of interest as exhibiting the steps forward in scholarship and in the energy and enterprise of research which it exhibits. The work of Lea on the activity of the "Inquisition in the Middle Ages" and the more recent one of Taylor on the "Medieval Mind" are treasure houses, somewhat dreary, it must be confessed, for the future student, but this book of Thorndike's, for fullness and completeness of reference, for excellence in presentation, for thoroughness of scholarship, leads them all. The reviewer is not familiar with any recent works in this field in foreign languages which can be compared with it. The preface reveals in outline the vast labor undergone, as intimated by the author, and the diligent reader on finishing it will find the author has not exaggerated it, indeed his modesty has not done justice to it in his own account.

In a subject so dull, even so repellent to many readers, he has labored to relieve the tedium of perusal by many touches of humor, but there might well have been more of them, for the record is a long and tiresome one—a record of the imbecility of the human mind at its worst since it has found a method of perpetuating its workings in cursive script. An essay on some aspect of the subject of magic may be made attractive by picking out the high points which allure, but to write an exhaustive and at the same time an attractive compendium of it is another matter. To combine with it an exposition of the springs of what we call experimental science makes it a task

calling for the strength of a Hercules and the omniscience of Jove. In fact the history of experimental science in this connection does not stand forth as it should if Dr. Thorndike were a demigod. In the matter of the exposition of medieval magic the book leaves little to be desired, but for the exposition of the sources of experimental science one must look elsewhere in some future compendium that goes far back of Galen. Such a work should expose more fully the experimental side of Galen's activities. His work on the arteries, but for the impediment of his theories, should have led to a very much better comprehension of the circulation of the blood long before Harvey. His experiments on the spinal nerves and the utilization of the vivisection of apes for the purpose might well have crowded out of Dr. Thorndike's book some of Pliny's drivel. In beginning magic with Pliny the author does not perhaps go far wrong, but experimental science does not begin with Galen nor with the school at Alexandria either, for that matter. Pliny's primitive magic, it is true, was probably already old in the world, and in written history there seems little to cavil at if a start is made with his Natural History, but not so as to experimental science beginning with Galen. This the author very explicitly admits and pleads very justifiably the law of limitations. Nevertheless, one must beware of thinking of magic and experimental science with its start at Pliny and Galen as one involuntarily does in this exposition of them.

It is natural to find Professor Thorndike in difficulties with definitions. "Let a woman spit three times in a frog's mouth and she will not conceive for a year," or, to choose again, this time an example of a technique difficult or impossible to perform, which is a notorious trick with magicians, Saint Hildegarde said, to get a really serviceable amulet you must catch a poisonous snake after he has skinned himself in a cleft of the rock and dry him for the purpose. There is no difficulty in defining these things as magic, but when we come to astronomy arising out of the hokus-pokus of astrology, a thing which the author seems unduly to deprecate, or of chemistry out of the supercheries of alchemy, we are on different ground and do not know which to call these activities of medieval monks, magic or experimental science. Now we don't have that trouble when we read Hippocrates or Aristotle; we have to go back to Empedocles for that. With him he must have begun if he was to justify his title as to experimental science. He must have led us up the crest of the wave to the pinnacle of the glory of Greece and down again to the trough of the sea with Pliny and Sextus Empiricus, but even back of them lies a magic, Babylon and Egypt and the Zend Avesta and the Rig Veda and the Poem of Gilgamesh. Now Professor Thorndike realizes all this and there can be no criticism for his curtailment of the subject, but he should have left "experimental science" out of his title if he was going to begin with Galen and give us so little of it even with him.

There are certain defects perhaps unavoidable in thus breaking arbitrarily into the full current of the evolution of thought in the domain of magic and science, admitted though the necessity must be for curtailment. The man-eating ants who mined gold for Prester John and the emetic recommended once a week in the Secret of Secrets of the Pseudo-Aristotle, Hildegarde's boiling of swamp water for drinking purpose, as Cyrus did for the waters of the Choaspes, might all have been found in Herodotus. Even the mistake about respiration of goats through their ears is found in the fragments of Alcmaeon long before Herodotus. Spitting magic came straight out of Egyptian papyri from the primitive magic back of them. The magic of numbers goes back of Pythagoras and is found in far lands which knew naught of any intellectual matters in medieval Europe. Belief in the gods did not antedate magic, but that is a matter of definition again into which we can not go. The Virgil of our modern editions of the Georgics II says nothing at line 480 of gems or herbs or of the minds and wrath of brutes, of fruits or reptiles. Hugh of St. Victor gives quite another hue to the color of line 479 by finding them in his edition, quite a magical atmosphere, which in reality Virgil did not breathe so copiously as the middle ages would make us believe. Comment on this is unfortunately lacking in Professor Thorndike's account. Perhaps he hardly meant to attribute to Galen Alcmaeon's theory of the wave nature of sound, but so the reviewer reads it in the text. The story of Galen catching the lady in love with a play actor is the exact counterpart of a story attributed to Hippocrates in the malady of Prince Perdiccas and more plausibly the same story was told of Erasistratus, because in his time all Alexandria was agog with interest over Herophilus and his work on the pulse. If he had started at the beginning of experimental science with the Greek philosophers, for instance, we would have found the author experimenting in a spurious book of the Hippocratic Corpus with the question of drink passing into the lungs and making a mistake as even scientific experimentalists will do occasionally. As to various other matters relating to the theories of elementary cognition the author might have found a summary in the excellent work of Beare on the subject dealing with work of the predecessors of Aristotle. Whatever Hero of Alexandria may have done in his day, the phenomenon of air pressure on a column of water was adequately demonstrated by Empedocles with his clepsydra. It was primarily on these Adelard of Bath must have based his elaborations. It is interesting,

however, to see the mind of Peter of Abano filled with a hopeless longing for a knowledge of the atomic weights of the elements, but it is not stated if he was guided thereto by Archimedes' celebrated discovery of specific gravity.

Roger Bacon fares badly at the author's hands, one is afraid, because we all in the last twenty years or so have been fed up on Bacon (no pun intended). The guides in Rome irritated the Innocents Abroad by all but ascribing the creation of the world to Michael Angelo, and we have grown a little sensitive about Roger Bacon being wholly responsible for the creation of experimental science, and Professor Thorndike stands so straight on the subject he seems to the dispassionate reader to lean over backwards a little For any one who has wrestled spiritually as well as physically with the tomes of Albertus Magnus, who seems to be his hero, it would be easy to make the Swabian leviathan somewhat of the same kind of a bore. One is, as it is, tempted to say he owes his fame to longevity and industry

There is a tendency to the repetition of certain phrases, which jars the attentive reader a little, there are some words used which are not to be found in the Century dictionary, some slips, but very few, in proof-reading. Indeed, such minor blemishes are exceptionally scarce for a work so extensive. Some perhaps not so negligible may nevertheless be passed over. It is hardly justifiable to refer further to these comparatively few shortcomings, since there is not more space permitted for an appreciation of the merits of a book which is, on the whole, an ornament to American scholarship.

JONATHAN WRIGHT

SPECIAL ARTICLES

ON THE ADAPTATION OF WHEAT TO GROWTH MEDIA DEFICIENT IN NUTRIENTS

IN the correlation obtained between differences in yield of grain of different varieties of spring wheats and that of their relative earliness of maturation appears a relation that suggests a factor which presumably plays no inconsiderable rôle in the adaptation of variety of wheat (and probably other plants) for maximum grain production from growth media markedly deficient in essential salt elements. Of nine different varieties grown in such a medium, the largest yield of grain, 200 milligrams per culture (average of 20, each containing 5 plants), was produced by the variety that ripened first, and the lowest yield, 46 milligrams per culture, produced by one of the last maturing varieties. The other varieties produced yields of grain that fell between these two limits, and the magnitude of yield generally corresponded with the relative earliness of the variety. Seven weeks elapsed between the time the earliest and latest varieties ripened. There was no correlation between the total dry weights of the different varieties and their comparative earliness. The average dry weight produced per culture was approximately 1.3 grams, regardless of variety.

The plants were grown in tap water, which as a growth medium can be defined as being markedly deficient in essential salt elements. Its osmotic value was equal to approximately 0.12 atmosphere osmotic pressure, with the ions Cl, So_4, Ca and Mg constituting the major portion of the solutes. The grain per culture was that which five plants produced, having available to them only those solutes contained in two quarts of tap water (two quart Mason jars were used as the culture containers) plus that which the seedlings 6–9 cm. high, germinated in tap water, contained when set in culture jars and one-half c.c. of .01 mol. solution of $FeSO_4$ per culture added at the beginning of the experiment. When the plants were six weeks old, from 300 to 500 c.c. of distilled water were added to each jar, this being the only change or addition made to the original two quarts of tap water.

As there was no correlation between differences in yield of grain of the different varieties and that of their relative earliness of maturation when they were grown in fertile soil, the question may be asked as to causes operative to bring about the results obtained when tap water was used as the growth medium. It appears that the tap water had no particular merit per se other than being a growth medium, deficient in nutrients, which enabled that variety of wheat that completed its growth cycle in the shortest period of time (that is, an early wheat) to utilize that small supply of salt elements most efficiently in the production of grain. Granted that the rate of utilization of nutrients for similar processes in these wheats was about the same, and that some of the nutrients were used in such a way during the vegetative growth period of the plants as to preclude their later utilization for the production of grain, then obviously the wheat which has a long-growing period, being a late variety, has less nutrients available for grain production than has an early variety. Whether a variety of wheat is early or late undoubtedly is largely determined by genetic and environmental factors, but the result of these factors—that is, whether the variety is early or late—in no small measure determines to what extent that minimum supply of salt elements in the growth medium can best be utilized for the production of grain.

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